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THE WESTON DYNAMO-ELECTRIC MACHINE.

The mechanical and electrical details of the Weston dynamo-electric machine have been very carefully studied, and it is probably unrivaled in efficiency, simplicity of construction, strength, durability, the ease with which it can be repaired in case of accidents, and excellence of workmanship and materials.

The general construction of this machine is shown in our engraving. The field magnets are placed in a horizontal position on each side of the armature, and their cores, pole-pieces, and yoke-plates form a rectangle of cast-iron which serves as the frame of the machine. The yoke-plates at each end are carried down so as to form feet, which support the machine, and the supports for the armature bearings are cast in one piece with the frame.

The armature is cylindrical in form, and its iron core is built up of a series of iron disks placed side by side, but separated slightly from each other. This construction is shown in Figs. 3 and 4, in which also a single disk is shown.

In this way the armature core is split up into a large number of separate sections insulated from each other by air spaces at every point (except very near the center). By this peculiar construction of the armature, induced currents in the core are almost entirely prevented, and the loss of energy and consequent injurious heating of the core, so common in other dynamo-electric machines, are entirely avoided.

In order to still further increase the efficiency of the machine, the armature is constructed to operate as a fan or blower to produce a rapid circulation of air from the center to the periphery, through the sectional core, thus cooling the conductors on the armature, and keeping their resistance much lower than would be the case if this method of construction were not used. The coils are wound lengthwise of the armature, and connected to the commutator at the end. The complete armature is shown in the cut below. By the peculiar winding of the coils on the armature, and their connection with the commutator, the highest possible efficiency is secured, and the coils are so perfectly balanced electrically that the spark on the commutator is hardly appreciable.

Owing to the rigidity of the bearings and general excellence of design and workmanship, the armature can be revolved between the poles with an extremely slight clearance—a condition very favorable to high efficiency.

The coils exciting the field magnets, instead of being placed in the main circuit in the usual way, are placed in a branch or derived circuit of high resistance, and only a very small fraction of the entire current passes through them. Great advantages are secured by this arrangement of the field coils. Less current energy is expended in sustaining the field, the current is more steady, and the machine more uniform in its operation; it is impossible to injure the armature by short circuiting the main circuit, and a perfect and extremely economical system of regulation can readily be applied.

The efficiency of this machine is extremely high. Recent tests have shown that over ninety per cent. of the power applied at the driving-pulley is available as useful current in the working or lamp circuit.

The company are making various styles of arc lamps for use with these machines, two of which are shown in the cuts. These move only the upper carbon, and are especially designed for burning in series, but work equally well as single lights. All the working parts and electrical connections are entirely inclosed, and are thus not only protected from dust and the weather, but are insulated in a very thorough manner.

The feeding mechanism, although simple in construction, is extremely sensitive and positive in its action and not liable to get out of adjustment. Its construction will readily be understood by a glance at Fig. 7.

A marked peculiarity of the Weston arc system is the shortness of the arc of separation between the carbons, the Weston arc being about one thirty-second of an inch in length, as compared with one-sixteenth to one-eighth of an inch in other systems. This enables a given number of lamps to be worked with a current of correspondingly lower tension. Comparatively low tension and freedom of the current from all vibrations or pulsations obviate the danger to life which numerous fatal accidents have shown to be very serious in other systems.

No person has ever been in any way injured by the current from a Weston machine, although workmen have acci-

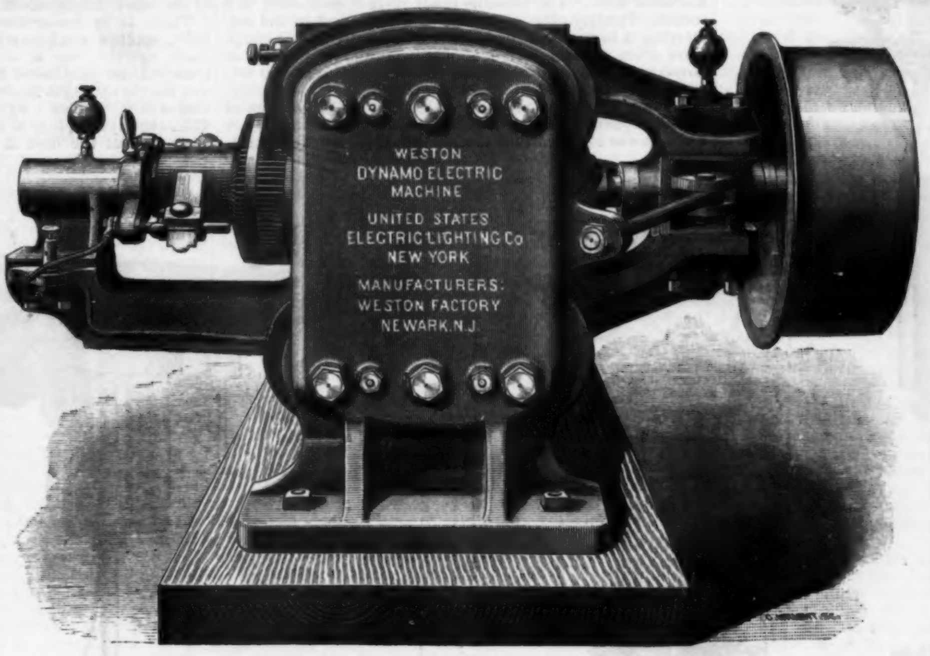


Fig. 1.—THE WESTON DYNAMO-ELECTRIC MACHINE—END VIEW.

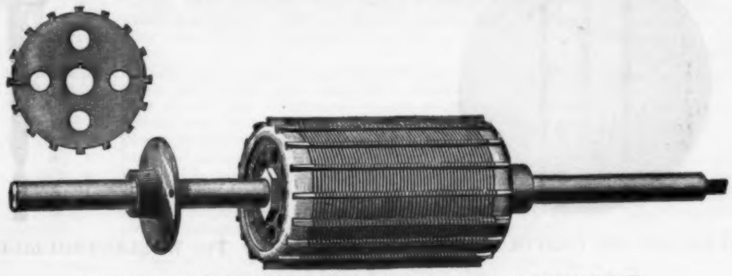


Fig. 3.—WESTON ARMATURE CORE AND SINGLE DISK.

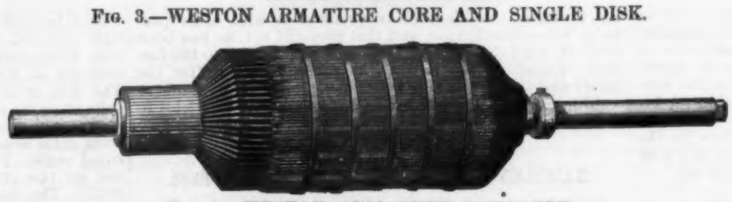


Fig. 4.—WESTON ARMATURE COMPLETE.

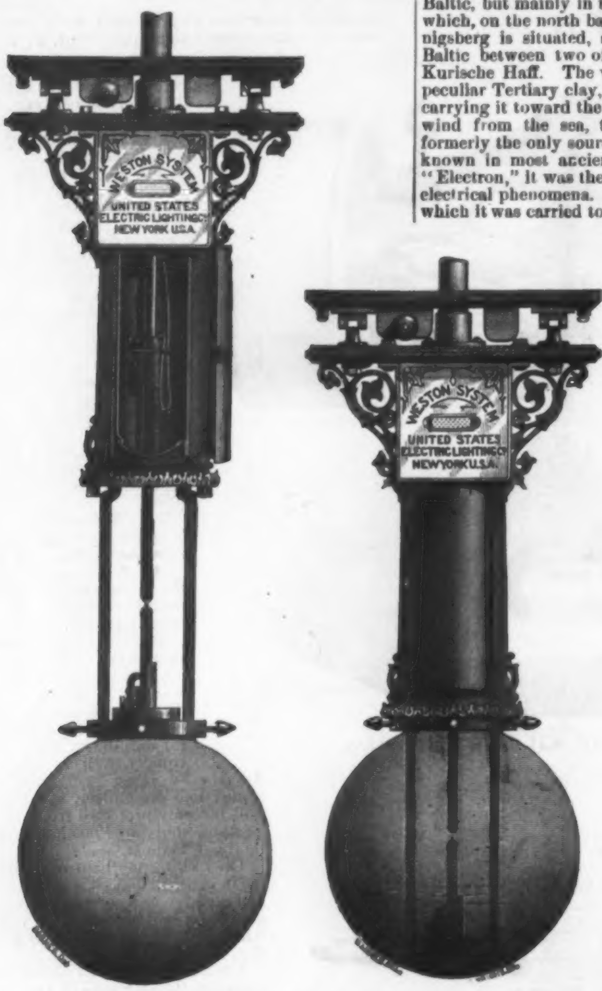
Fig. 2.—THE WESTON DYNAMO-ELECTRIC MACHINE—SIDE VIEW.

dentally received shocks from forty and fifty light circuits, under substantially the same conditions as have rendered such shocks fatal with other systems.

As regards danger to property, this system is, with the exercise of the most ordinary care in erection and management, much safer than lighting by oil or gas, and this fact is well recognized by fire underwriters throughout the country.

More light is said to be produced per horse-power by the Weston system than by any other running several lamps with a single machine.

The difference in color between the light from a long arc and that from a short arc is quite marked. The excess of blue and violet rays in the long-arc light gives it a peculiar tinge which is very disagreeable and trying to the eyes.



FIGS. 5 AND 6.—INCLOSED FRAME ARC LIGHTS.

FIG. 7.—ELECTRIC LIGHT MECHANISM.

This is entirely obviated by the use of a short arc, such as has been adopted in the Weston system, as the illuminating effects are produced almost entirely by the incandescence of the carbon points, and the light is softer and more agreeable to the eyes, and in color more closely resembles sunlight. This is an especially important consideration for interior illumination.

The light is also steadier, as the slight impurities in the carbons, which produce an almost constant tremor in a long arc, do not sensibly affect the steadiness of a short one.

ELECTRIC EXHIBITION AT KONIGSBERG.

IT will be new to the greater number of our readers to learn that an electric exhibition has been open at Königsberg, in Prussia, since the end of April. It was projected with the view of giving to the population of a large district, separated by very considerable distances from the central and more favored parts of the kingdom and empire, an opportunity of becoming familiar with a subject of which, under other circumstances, they must have remained ignorant, as they are but little accustomed to travel. Königsberg, a strongly fortified and university town of 125,000 inhabitants, stands on the Pregel, which goes to the Frische Haff, one of the bays of the Baltic; it is the capital of the province of East Prussia, which has plenty of lakes and forests, but, if we except the coast line and the rich and fertile districts of the Vistula delta, a sterile soil, and a scanty, poor population.

The nearest large town, Dantzic, is 130 miles distant, while Berlin is more than 300 miles. To the south there is Poland, with its single important and capital town of Warsaw, at 180 miles distance; and on the east there are those parts of Russia which have a strong German element. To start an electric exhibition at Königsberg was, therefore, an enterprise similar, perhaps, to opening one at Aberdeen. But such an exhibition may serve the interests of both the public and the manufacturer just as well as some of those which have taken place in more important towns. There was no Crystal Palace available at Königsberg; but suitable accommodation has been obtained in the public gardens belonging to the town. A fine Renaissance building has been erected and tastefully furnished to show the various appliances of electricity for domestic purposes, and most of the fourteen groups into which the exhibits are divided have been quartered in special pavilions.

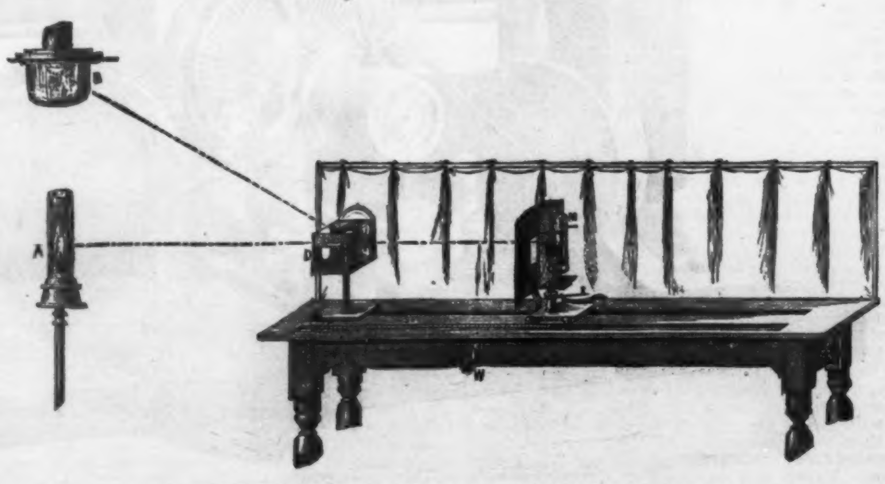
The historical and educational group contains, besides others, the very valuable collections of scientific and technical instruments of the university and various institutions of Königsberg; one section has been assigned to the medical group; further, a very instructive and complete reading room has been established, to which nearly fifty of the leading publishing firms of Germany have contributed copies of their respective works and periodicals. Batteries, etc., have been supplied by eighteen exhibitors; telegraph apparatus by various firms and the Eastern Railway, which is under Government management, like most of the important German lines; there are more than forty dynamos employed as light machines, besides a number of others for electro-plating; for these, fifteen steam and three gas motors are at work, and there are several hand dynamos. To illustrate the illumination of ships, a ship's skeleton 200 feet in length by 50 feet in width has been erected. There is telephonic connection with the Königsberg opera, an electric railway, and, of course, no lack of refreshment rooms.

The apparatus which, with the help of the electric light, is to illustrate the diving operations for collecting amber, deserves special mention. Amber is found in larger or smaller quantities all along the south and east coast of the Baltic, but mainly in the rectangular peninsula of Tamland, which, on the north bank of the River Pregel, on which Königsberg is situated, stretches from east to west into the Baltic between two of its bays, the Frische Haff and the Kurische Haff. The valuable fossil resin is embedded in a peculiar Tertiary clay, out of which it is washed by the sea, carrying it toward the shore, where, especially after a rough wind from the sea, there is eager searching. This was formerly the only source of this resin, which it appears was known in most ancient times; in which, under the name "Electron," it was the first object used in the production of electrical phenomena. There is no record of the manner in which it was carried to the more civilized parts of the world, but probably the Phœnicians obtained it with other products by overland trade, and that they did not, as has been asserted, send their ships all round Europe and into the furthest recesses of the Baltic. At present, digging for the amber and sifting the clay is deemed almost as profitable as waiting for what the sea throws out voluntarily, or yields to the diver.—*Engineering.*

HARTLEY'S "UNIVERSAL" PHOTOMETER.

THE illustration represents a new and exceedingly simple form of photometer designed by Mr. F. W. Hartley, of Millbank Street, Westminster. It is intended for the easy measurement, in any situation, of the illuminating power of lights of any size in any position, in the horizontal plane of the instrument, or at an angle with it. The first instrument of this class has been made and used for the tests of burners now in progress in connection with the judging of the exhibits at the Crystal Palace. The examiners have found the arrangement so convenient that they now use it exclusively for the purpose, with the Methven 2-candle screen. The latter standard, from its handiness, presents itself as the right one for a simple and withal exact appliance of this class; although, of course, any other is suitable. The apparatus consists of a table with two long slots in its surface. In one of these lies a movable scale, S, graduated in inches and tenths; and in the other slides the standard light, M, by means of the winch, W. The light to be tested stands quite apart from the table, as at A or B; and according to its intensity may be 20, 30, 50, or 100 inches horizontally or diagonally from the screen, D, when adjusted to zero of the scale, as shown in the drawing. For all these determinate ranges, which give the operator the power of testing with a 2-candle standard a light up to 555·6 candle power, there are tables provided to obviate the necessity of calculation; although, as the readings are in linear measurements, the range of the instrument may be increased to any required extent. For angular measurements, Mr. Hartley has devised a scale for determining the hypothenuse, or the direct path of the light rays to the photometer disk, which is a noteworthy addition to the handiness of the whole arrangement.

There is in connection with angular measurements of light, another consideration for which provision is to be made, and this may be stated as follows: In ordinary photometers the contrasted flames are on a level with the disk, and the rays of light impinge upon the disk at nearly right angles to it. When a light is above the level of the upright disk, the rays impinge at a lesser angle and in smaller numbers; so that the disk is not so strongly illuminated as it would be with the light on the same level. Hence such light elevated, when contrasted with a standard delivering rays horizontally, appears less powerful. There are two methods of testing an elevated light by the aid of a disk. The first is to set the disk vertically. In this case the results show the relative power of light falling upon a vertical plane. The second is to set the disk so that the rays of light from each source shall fall upon its opposite sides at an equal angle. Thus, if the rays from the elevated light would fall on the ground at an angle of 45°, the disk is set at 22·5°. The first method, as might be expected, gives the lowest results, as the lighting power of the standard is not affected; and it gives the real effect which would be produced upon a wall, and the power (nearly) of the light which would fall upon the ground within a space defined by lines cutting the edge of the disk to the ground. With the second method the standard is weakened and more rays seem to reach the disk—indeed, must do so—from the elevated light. In this method we have an approach to the lighting effect upon a book in reading; and the relation is between a standard weakened against an opposed flame weakened.



HARTLEY'S UNIVERSAL PHOTOMETER.

Thus in testing a flame elevated Mr. Hartley found the following data:

Disk vertical, light at an angle of 45°	3·98 cand.	=	70·82 per ct.
" inclined, 22½° to an angle of.........	5·16 "	=	91·81 "
" vertical, light horizontal	5·62 "	=	100·00 "

The particular burner was a special kind, and rendered a much higher duty angularly than ordinary Argands or flat-flames, being assisted by a reflector. But it is quite apparent that the setting of the disk at a mean angle does not cause an indication of power equal to that realized horizontally.

There are many occasions for the use of a photometer of this order, in which, while the range permitted to the observer is great, the fixtures and appliances generally are reduced to the minimum. Hr. Hartley has again done excellent service to gas managers by placing such an apparatus within reach of everybody.—*Journal of Gas Lighting.*

THE NEW YORK AND BROOKLYN BRIDGE.

THE practical completion of the grandest piece of bridge engineering the world has yet seen necessarily attracts attention, not only in the immediate vicinity of the work, but throughout the civilized world; not only from curious sight seers, but from those who labor for the advancement of their fellows and rejoice in the success of a stupendous undertaking. In many respects this bridge has been an innovation, not only because of its vast proportions, but because of the materials entering into its construction. From time to time during the past thirteen years we have described and illustrated the main parts of the bridge at the time of their being finished, yet we do not think it amiss at the present time to summarize as briefly as possible the dominant features of this triumph of the science of engineering.

On the 16th of April, 1867, the Legislature of New York passed an act incorporating the New York Bridge Company, for the purpose of building a bridge over the East River between the cities of New York and Brooklyn. On the 23d of the following May, John A. Roebling was appointed chief engineer, and toward the close of the same year made his report, discussing at some length the three routes and the practicability of building suspended bridges of long span. The charter fixed the Brooklyn terminus at the junction of Main and Fulton Streets, but allowed the New York terminus to be at or below Chatham Square, but not south of the junction of Chatham and Nassau Streets. Considering the value of the property to be condemned, the grades, the difference in the cost, and the fact that City Hall Park would remain the center of travel for many years, it was thought best to build on the Park line. During the summer of 1869, a detailed survey of the route was made, and the Brooklyn tower located. It was while engaged in this work that Mr. Roebling met with a most serious accident. His right foot was crushed by the shock of a ferry boat against the fender rack of spring piles on which he was standing. Lock jaw set in, and after sixteen days of extreme suffering terminated in his death. In August of the same year his son Washington A. Roebling was appointed chief engineer.

The plan of the bridge was approved by the Secretary of War, and under date of June 21, 1869, the Chief of Engineers wrote to the company stating that under no conditions must the center of the span be less than 135 feet above mean high water; no portion of the tower foundations above the river bed must project beyond the pier lines; and no guys must ever be attached to the main span which will be below the bottom chords of the bridge.

An act was passed June 5, 1874, changing the name to that of the New York and Brooklyn Bridge, and making it a public work to be constructed by the two cities, Brooklyn paying two-thirds of the cost and New-York one-third.

Taken as a whole the bridge consists of the approaches, one at each terminus; station buildings at the extreme ends; an anchorage, at the end of each approach, to which the four cables are fastened; two towers, over which the cables pass. To the cables are secured ropes on which hang six systems of longitudinal trusses, connected transversely by floor beams, dividing the width of the bridge into two roadways, two carways, and one promenade.

Work was commenced on the foundation of the Brooklyn tower on January 3, 1870. Borings, made previously, showed gneiss rock at a depth of 96 feet below high water, above which were layers of hardpan and trap bowlders embedded in clay and sand. This was considered compact enough to form a satisfactory foundation without going more than 45 or 50 feet below the surface of the water. Timber immersed in salt water is, practically, imperishable, and if placed below the bottom of the river will be out of reach of sea worms. It was therefore decided, in order to secure a bed of uniform character, to build a solid timber foundation having strength sufficient to act as a beam, and weight to insure even settling. The magnitude and importance of this feature in the great work becomes apparent when it is known that it would be called upon to sustain a dead weight of some eighty thousand tons.

The caisson was an immense box having a roof and sides but no bottom, so that when it was placed over the site and sunk, the water would not rise in the interior beyond the edges, thus forming an air chamber in which the men were free to work. The caisson was 102 feet wide, 168 feet long, the height of the air chamber being 9½ feet. A section through the sides formed a V, the inner slope of which had an angle of 45 degrees, and the outside of all the walls had a batter of 1 in 10. The walls sloped down to an edge, or shoe, formed by a semicircular casting, protected by boiler plate extending 3 feet up the sides. The timbers forming the V were held together by drift and screw bolts, and secured to the roof by angle irons and common timbers. The roof, upon which the tower was to rest, consisted of fifteen courses of Georgia pine timbers 12 inches square, alternate courses being laid in the same direction, and the pieces bolted both horizontally and vertically. To make the caisson air tight the seams were thoroughly calked, and in addition, a vast sheet of tin was inserted between the fourth and fifth courses and down the four sides. There were shafts cut through the roof of the caisson for the passage of the laborers and to take out the excavated material and admit supplies. There were two water shafts made of boiler plate three-eighths of an inch thick, and having a rectangular section 7 feet by 6½ feet. These shafts were open both above and below, and the lower end extended below the edge of the shoe for 21 inches. Through these shafts descended dredges which grappled and raised any substance placed beneath the opening. There were two air shafts, 3½ feet in diameter, having an air-lock at each upper end, for the use of the men. The supply shafts were cylindrical, 21 inches in diameter, and furnished with two doors, one above and one below. To admit material the lower door was closed, and the tube filled with the desired objects, after which the upper door was closed. The valve to the equalizing pipe was then opened, and as soon as the air pressure in the tube was equal to that in the chamber the lower door was opened, when the material fell into the chamber. All the doors to the air locks, as well as those to the shafts, fitted closely and swung into the chamber having the greater air pressure. Five massive frames, or walls, divided the air chamber of the caisson into six compartments. When this great box had been finished, it was launched and towed to its future resting place.

During the building of the caisson the site of the foundation had been cleared, and a rectangular space a little larger than the caisson, and having a depth of water sufficient to float it, had been prepared. On May 1, 1870, the caisson was towed down, and on the following day was warped into position. The tower proper was now commenced on the top of this caisson, but it was not until three courses of masonry had been laid that the caisson was weighted sufficiently to rest firmly on the bottom and resist the action of the tides. Six air compressors had been placed on the surface for the purpose of supplying air to the air chamber of the caisson. The pressure in this chamber was kept equal to the hydrostatic head, differences in the materials passed through making slight deviations from this rule necessary. The work of excavating was carried on from the chamber, all obstructions being removed from under the shoes and frames. At the same time the masonry was being laid on top with the aid of boom derricks and engines. When bowlders were encountered too large for easy handling, they were pulled out of the way by hydraulic jacks, then drilled and blasted. The blast produced no ill effects on the men, although some trouble was anticipated owing to the dense atmosphere.

Gradually but surely the caisson sank toward its final resting place, while the tower grew above it. At the end of five months 20,000 yards of earth had been removed. As the caisson proceeded downward the disproportion between the load above and the buoyancy became more and more, and to support this overweight additional shores were introduced, which rested upon a block and wedges and supported a cap placed against the roof. When the caisson had reached within three feet of its journey's end, 72 brick piers were built having bases averaging 20 square feet. These had strength enough to uphold the whole mass if the air pressure should from any cause be removed. When the caisson had reached a depth of 44½ feet below mean high tide, the operation of filling the entire air chamber with concrete was begun. The concrete consisted of one part of Rosendale cement, two of sand, and three of small sized gravel. The total quantity required including the brick piers, was about 4,000 yards.

The danger from fire in an atmosphere of compressed air is very great, and the difficulty of quickly subduing it makes every known precaution necessary. At a pressure of 25 pounds to the square inch, the flame of a candle will return after having been blown out. On December 2, a fire was discovered in the caisson after it had been going some hours and attained considerable headway. Streams of water, steam, and carbonic acid were successively tried, but availed nothing. After struggling unsuccessfully for some time, the caisson was flooded, and left so for two and a half days.

When the air was again admitted and the water expelled, about 200 borings were made in the roof to ascertain the extent of the fire. Vertically it was confined to the third, fourth, and fifth courses of timber, but laterally it extended to points 50 feet apart. Holes were made in the roof, the charcoal scraped from every burned stick, and the holes filled with cement. In order to prevent any settling at this point, a pier of square blocks of trap rock was built directly under the space burned. Cleaning and filling the burned section occupied 18 carpenters, working day and night, two months, besides common labor.

The Brooklyn caisson, completed, contained 250 tons of iron and 111,000 cubic feet of timber.

The New York tower is located in a direct line from the Brooklyn one, perpendicular to the stream, and at a distance of 1,595½ feet. Borings on the site did not encounter rock before reaching a depth of from 77 to 92 feet below high water, and as extensive beds of quicksand rested on the rock, it was necessary to go to it for a firm foundation. As this caisson would ultimately be subjected to a much greater pressure than the one upon the other side, the dimensions were made 102 by 172 feet. The roof was 22 feet thick, surmounted by a coffer dam reaching to high water mark, thus increasing the buoyancy and lessening the pressure on the frames during sinking. The air chamber was 9½ feet high, and divided into six compartments. The interior of the chamber was lined with boiler iron, riveted together and calked. This lining made the chamber airtight and guarded against fire. Two sets of double air locks were built into the roof of the caisson, each being 6½ feet in diameter by 8 feet in height. There were four supply shafts, two of which were 24 inches in diameter and two 21 inches. The caisson was sunk to a depth of 78 feet in a manner very similar to that pursued on the other side, but owing to the nature of the material passed through, sand pumps were introduced, which utilized the air pressure in the chamber to force the sand out through tubes. The air chamber was filled as in the other case, except that the brick piers were deemed superfluous owing to the greater strength. The New York caisson contained 180 tons of bolts, 200 tons of iron work, and 118,000 cubic feet of timber.

The tower is not a solid mass of masonry, but consists of three buttressed shafts, joined together up to the roadway by four connecting walls. In the Brooklyn tower the course next the caisson is 17 feet thick; the thickness diminishes by offsets until at high water it is but 10½ feet. This forms two well holes, which are filled with concrete below water line, but left open up to the roadway. Spaces were also left from 2 feet above the arches to within 4½ feet of the top of the tower.

In one of the wide shafts is a small vertical opening 2 feet 5 inches by 3 feet, connecting with one of these small spaces. By means of a trap and iron ladder access can always be had to the roof. Above the roadway the tower consists of three columns having an oblong section, and united at the top by arches having a span of 39¾ inches. The points of the arches are 114½ feet above the roadway. The arches are pointed and are formed by the intersection of two arcs of circles having a radius of 48½ feet.

In order to guard against any possible change of form, heavy irons were inserted in the masonry and rods placed across the span. The masonry of the towers below water is largely limestone, except the facing of the two upper courses, which is granite. The backing above high water to the roadway is mostly granite, and all the remainder of the work is granite. To raise the stones from the yard at the foot of the tower to the work, engines driving drums were used. About the drums was wound a rope which passed over a pulley on the top of the completed course of the tower. A lewis having been put in the stone to be raised, it was attached to the rope and hoisted to the top. Here a car running on rails projecting over the edge was run under, and the stone lowered on it. Having reached the tower, the derricks carried it to its destination. Upon the upper portion of the work balance derricks were used instead of the boom derricks.

The vertical dimensions of the towers are as follows:

Height of roadway above mean high tide, 119½ feet; height of springing of arches above high tide, 198 feet; height of springing of arches above roadway, 79½ feet; height of ridge of roof stone, 271½ feet. The height of the ridge of roof stone of the Brooklyn tower above bottom of foundation is 316 feet. In the New York tower the height of ridge of roof is 349½ feet. A balustrade around the towers will increase the height to 276 feet above tide.

The following are some of the horizontal measurements:

At the top of the caisson the Brooklyn tower is 151 by 49 feet, and the New York tower is 157 by 77 feet; at high water the Brooklyn tower is 57 by 141 feet, and the other 59 by 141 feet. At these points the towers have a solid section. At the base of the three shafts, or roadway, the Brooklyn tower is 45 by 131 feet; at the springing of the arches, 42½ by 128½ feet; at the base of the upper cornice it is 40 by 126 feet. The openings in the towers are 33¾ feet wide. Above high water the New York tower differs from the other by an increase of 3 feet in thickness in the direction of the axis of the bridge. The total weight of the Brooklyn tower, masonry and timber, is 93,079 tons. The greatest pressure at any point in the tower masonry will be at the base of the central shaft above roadway; this will be about 26 tons to the square foot, or 361 pounds per square inch.

At a distance of 930 feet from each tower is an anchorage designed merely to resist the pull of the cables which pass over the towers. These rest on timber foundations, the spaces between the sticks being filled with concrete. The masonry of the Brooklyn anchorage is 4 feet above tide, while the other is at high tide level. The Brooklyn foundation is 119½ by 132 feet; New York foundation, 119½ by 138 feet. The masonry is similar. The work is solid with the exception of two openings or tunnels, in the river side, which are arched by semicircular arches of 23 feet span, springing at from 62 to 66 feet above tide. The anchorages are about 90 feet high above tide level. They are built of limestone and granite. The Brooklyn anchorage contains 27,113 cubic yards of masonry; the New York, 28,803 cubic yards.

In the end of each anchorage furthest from the towers are four anchor plates (one for each end of each cable), which are held down by the dead weight of masonry piled upon them, and to which the cables are attached. The anchor plates in the Brooklyn anchorage are placed 8 feet above tide, and those in New York 6 feet. These plates are cast iron, 2½ feet thick at the center, and measure 16½ by 17½ feet on the surface. In form they much resemble an enormous wheel, having a massive hub and 16 spokes, but no rim. Each plate weighs about 23 tons. The cables enter the corner of the anchorage diagonally opposite the plates, and after traversing a short distance horizontally, make a curve of about 90 degrees to the plates. The wires composing the cable do not come much beyond the corner of the tower, the connection between them and the plates being made by anchor bars. These bars start in double sets from each plate, one curving over the other, and are vertical for a distance of about 25 feet, when they curve about 90 degrees on a circle having a radius of 49½ feet. They then extend to within 25 feet of the front of the masonry, where they meet the cable wires. The bars have an average length of 12½ feet; the first three sets have a section of 7 by 3 inches, the next three 8 by 3, the next three 9 by 3 inches; the tenth set is double in number, and each 1½ by 9 inches section.

Piercing the center of the anchor plates are two parallel sets of apertures, each set containing 9 holes. A bar is passed through each hole, and a bolt, or key, run through the eyes, or holes, which are in the end of each bar. These bolts bear firmly against the under side of the anchor plate, and serve to distribute the strain to every part of the plate. The next series of bars are attached to these by a bolt 5 feet in length and 5 inches in diameter. In this manner the succeeding bars are united, forming a chain having very long links connected to each other by bolts passing through the eyes. These bolts vary in size from 5 to 7 inches in diameter, according to the strain to be placed upon them. At each knuckle of the chains a large piece of granite was placed with a heavy cast-iron plate inserted as a bearing for the heads of the links. The bars in the last link are increased in number to 38, and are arranged in four courses, one above the other. The wires of the cable are divided into 19 strands, and each strand is fastened around a grooved eye-piece so as to form a loop.

The total dead weight in the anchorage is about 1,000,000 pounds, and the weight on the anchor plates is about two and one-half times the force exerted by the cables against it.

It now becomes necessary to get a rope from one anchorage to the other passing over the two towers. To do this a reel containing the first ropes was placed in a frame erected on a scow, moored in front of the Brooklyn tower. The end of the rope was then hoisted over the tower and drawn down on the other side into the yard Here it was fastened to a rope leading to an engine on the anchorage. Carefully it was hauled over, men being on the intervening buildings to protect them from injury. The scow with the reel was then towed across the river to the New York tower, where the other end was carried over the tower and down into the yard to the engine which had been used to hoist stone. Men were now stationed on the tower to watch the craft in the river, and when an open space with no boats near was obtained, word was given the engineer, who started up. Gradually but surely the rope was drawn over the tower; leaving the water, it rapidly rose until the desired deflection of 80 feet was reached.

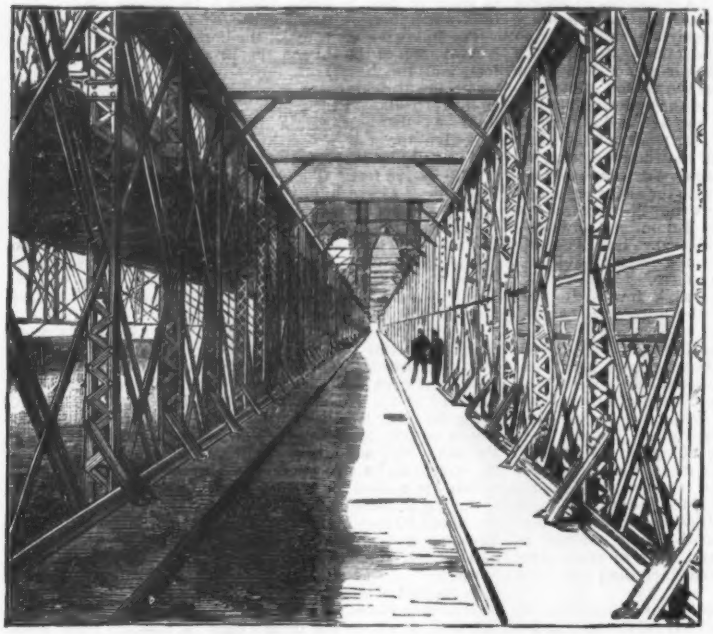
A second rope was taken over in the same manner. After having been fastened to the top of the tower, the ends of the two ropes were hauled over the buildings to the New York anchorage. The ends of these ropes were spliced together around the driving and guiding wheels placed on the New York anchorage, thus forming an endless rope moving to and fro. In this way the first path across the East River was placed in position. This traveler was made of galvanized steel wire, three-quarters of an inch in diameter. Shortly after another traveler was erected alongside of this one, the ropes being carried over by the one already up. The first rope was taken over August 4, 1876, and eleven days after Mr. E. F. Farrington, master mechanic of the bridge, passed

over the span, seated in a boatswain's chair. After this there were suspended a "carrier" rope $1\frac{3}{4}$ inches in diameter, and designed to bear the weight of the heavier ropes while being carried over; three cradle ropes $2\frac{1}{4}$ inches in diameter for supporting the cradles; two foot bridge cables; one auxiliary rope; two storm ropes attached to the foot bridge, and to each of the towers below the roadway, in order to prevent the wind from lifting the foot bridge; two ropes for band rails for the bridge.

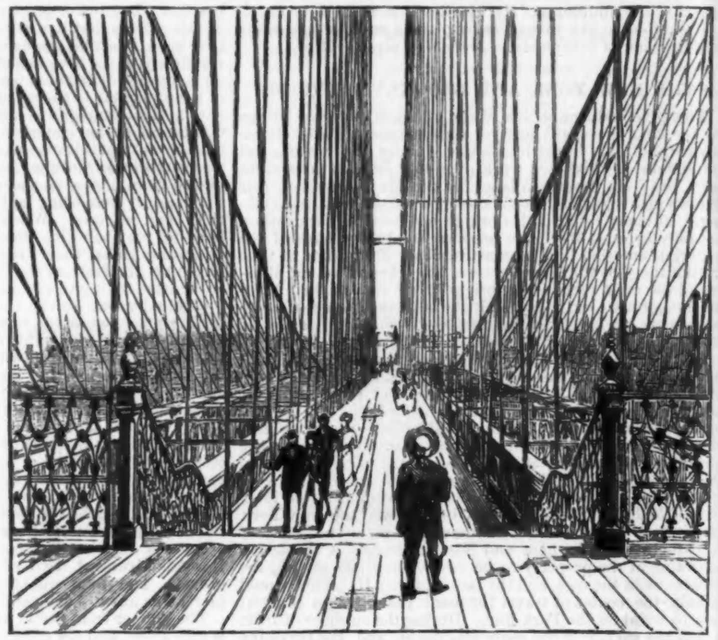
The cradles, ten in number, were nearly 48 feet long, placed perpendicular to the axis of the bridge, and arranged so that the strands of the main cables would be within easy reach of the men. The foot bridge was made of oak slats 3 by $1\frac{1}{2}$ inches, laid two inches apart, and fastened to longitudinal strips which were secured to the ropes.

All the work we have heretofore described was erected for the purpose of holding in position 6,800,000 pounds of steel cable wire. These wires are made of hardened, tempered, and galvanized steel, size No. 8, full, Birmingham gauge. A length of fourteen feet weighs exactly one pound. Each wire has a breaking strength of not less than 3,400 pounds, which is equal to 160,000 pounds per square inch of solid section. As the cables were to be suspended in a salt atmosphere, galvanizing was deemed the only sure safeguard against corrosion, and this was done at a temperature that did not affect the temper of the wire. Every known prevention was taken to have the wires conform to the standard as set forth in the specifications, and every lot was critically examined by inspectors appointed by the bridge, and pieces cut from the delivered rolls were being constantly tested by engineers. The cable making machinery was located on the Brooklyn anchorage. Each traveler ran around a driving wheel 11 feet in diameter on an upright wrought iron shaft, and by three guiding wheels. On the New York anchorage the traveler ran around two 4 foot wheels placed on a sliding frame, so that the slack in the rope could be taken up. These wheels were made of oak.

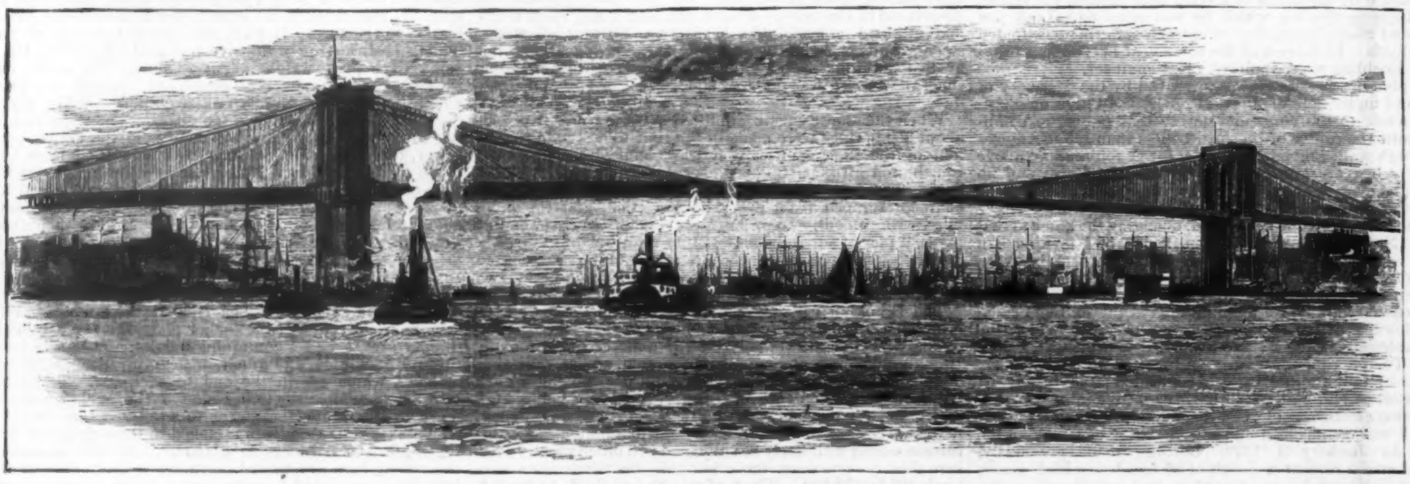
Placed in the wire shed on the Brooklyn anchorage were 32 drums having a diameter of 8 feet, face of 16 inches, and a depth of rim of 6 inches. These were to act as reels for the cable wire, and their working capacity was about 50,000 lineal feet. The first operation in actual cable making was that of adjusting four wires to be used as guides in obtaining the exact deflection of the balance. This was done by selecting four wires of uniform size and weight, and by adjusting them by referring to a tangent line for the land spans whose position had been calculated, and to a level line tangent to the lowest point of the curve for the center span. Allow-



VIEW SHOWING ONE OF THE RAILWAY TRACKS.



VIEW ALONG THE FOOT WALK.



GENERAL VIEW, SHOWING THE CENTRAL SPAN.

A VIEW FROM THE NEW YORK SHORE.

ALONG THE BRIDGE, SHOWING THE CABLES AND A TOWER.

THE NEW SUSPENSION BRIDGE BETWEEN NEW YORK AND BROOKLYN.

ances were made for the temperature prevailing at the time. A wire was fastened to the shoes in the anchorage, and then passed around a sheave which was attached to one rope of the traveler by iron arms from its axle.

The sheave carrying the bight then started on its journey to the other side, the speed of the traveler averaging 5½ feet per second, and as the wire ran out at twice the rate, 11 feet of wire were placed per second. On reaching the New York side the bight was passed around the shoe, when the sheave returned empty. The adjusting of the wire was commenced at the Brooklyn side. A tackle was attached to the wire as it passed over the Brooklyn tower, and it was hauled until the men stationed in the cradles previously mentioned signaled that it was up to the proper elevation, when it was held in that position on the tower. A tackle was then fastened to that part passing over the New York tower, and the river span was raised until pronounced all right. A similar operation was repeated between the tower and anchorage on the New York side, and the slack was taken around the shoe. The whole programme was again gone through with with the other wire, but in a contrary direction.

A strand consisted of 278 wires, and the first or lower one was finished and attached to the bars July 14, 1877. To keep the strands apart and prevent chafing, they were seized throughout their length at every 2½ feet and wrapped by about five turns of No. 14 annealed wire. Experience on the first strands showed that no difficulty would be experienced in obtaining a larger wire, and therefore it was increased to No. 7 instead of No. 8. This gave 11 feet to the pound instead of 14. After 12 strands had been finished, the central 7 (which formed the core of the cable) were brought together and bound at intervals. The last wire in the cables was run over October 5, 1878, and the 19 strands of the four cables were in place.

At a distance of 21½ feet from the anchor bars heavy clamps were put on the cables to draw them to a cylindrical form. This was made necessary, as the anchor bars spread so as to cover a space 5 feet square. The final work of wrapping the cables was now begun. The wrapping wire was No. 10 charcoal iron wire, drawn hard and galvanized. The wrapping wire was put on with a machine, and was very tightly drawn. The binding wires on the core were cut and clamps screwed on the cable in advance of the wrapping. As the work progressed, the whole was saturated with linseed oil.

1. Carriageway, railway, and promenade.—2. Stairway around tower.—3. Brooklyn approach, looking toward New York.—4. Brooklyn entrance, railway station, and boiler house.—5. New York entrance and railway station.

OPENING OF THE GREAT SUSPENSION BRIDGE BETWEEN NEW YORK AND BROOKLYN.

As the bundles of cable wire came in comparatively short lengths, joining was frequently necessary. The coupling was made of Bessemer steel wire 0·281 of an inch in diameter and 1½ inch long. This was drilled, and a right and left screw cut in each end respectively. Reverse threads being cut upon the ends of the wire, the coupling was screwed up. After having been galvanized, the joint was equal in strength to the wire. The cables are 15¾ inches in diameter, and each one contains 3,515 miles of wire wrapped by 243 miles of wire.

Passing over the towers alongside of the cables are a number of stays of steel wire rope. These stays are attached to the trusses carrying the floor system, and reach to a distance of about 400 feet from the towers, and at intervals of 15 feet. They are designed to sustain a portion of the load and to prevent vertical vibrations.

As the cables pass over the towers they rest in saddles, the object of which is to furnish a bearing with easy vertical curves. In plan they are rectangular, 13 feet long by 4 1/12 feet wide, and have an extreme height of 4¼ feet, and a thickness of 4 inches. One cable passes over the center of each through a groove 19½ inches wide and 17½ inches deep at the center. There are two smaller grooves on each side of the large one, in which four of the long stays are situated. Wherever there is a possibility of chafing the wire, the ends and edges are rounded.

To reduce the weight and secure uniformity in thickness, 17 openings were made beneath the grooves. Longitudinal edges are extended 1 inch below the under surface of the saddle to make bearings for iron rollers to be described shortly. The inner faces of these edges are true, and the under surface is planed so as to bear a straight edge in any direction.

The saddle-plates rest in seats prepared in the masonry and form absolutely true beds, on which the rollers travel. They are 16½ feet long and 14¾ inches high, the outside ones 8 feet wide at the center and 6¼ feet at the ends; the inner ones being 6½ feet wide at the center. The central portion is 4½ inches thick, and the sides 3¼ inches. The central channel is planed perfectly true, and the edges that form bearings for the rollers are also planed true.

Each saddle weighs about 25,000 pounds, and each saddle-plate about 11,000 pounds.

Between the saddle and saddle-plate are steel rollers, along which the saddle is free to move. By this means the cables are free to move backward and forward, and not only to accommodate themselves to any unequal loading that might occur during construction, but also to adapt themselves to changes caused by alterations of temperature and load after completion. All liability to wear while moving was thus obviated.

The floor system of the bridge consists of six longitudinal trusses, connected by floor-beams, the whole suspended from the cables by suspender ropes. Between the towers and on each side of them, with the exception of a short distance from each anchorage, the floors are below the cables. The suspender ropes are made of twisted steel galvanized wire, and are from 1⅝ to 1¾ inches in diameter. They are capable of sustaining about five times the load they will ever be called upon to bear, or about 50 tons. They are attached to the cables by wrought iron straps, ⅝ of an inch thick and 5 inches wide. The straps were placed on the cables when they were wound. The backs were heated in forges until they could be opened so as to admit the cable, when the two ends were drawn together, a thin plate of iron having been previously inserted between the cable and hot iron to prevent burning. The under side of the strap terminates in two lugs, ⅞ of an inch thick, through which passes an iron screw-bolt 1¾ inches in diameter, holding the wrought-iron closed socket on the upper end of the suspender rope. On the lower end of the rope is fastened a cast iron socket having a hole in each end through which pass two stirrup-rods to hold the floor beam. These rods have long screw threads by which the beam can be raised or lowered.

As the floor system of the bridge is in a continuous line with the surfaces of the anchorages, and the cables leave the anchorages a few feet below, the floors rest on the cables until the latter rise above the grade. The beams are laid on posts varying in height to suit the distances, and braced by plate brackets. The lower end of the post is bolted to the upper half of a strap encircling the cable. The total number of suspender ropes is 1,520, and the number of posts, 280.

The floor-beams were made in half lengths, and when riveted at the center made a continuous beam the width of the bridge, 86 feet from end to end. They are 32 inches deep, 9⅝ inches wide, and weigh 4 tons. Each one has two top and two bottom chords braced together, so as to form a triangular lattice girder. The chords are of steel channel bars. They are suspended 7½ feet between centers and an I beam placed between each pair, resting on truss chords, so that the planking will be supported at every 3¾ feet. The floor-beams were hoisted to the floor of the arches in the towers and then attached by ropes to their respective suspender ropes, when they were swung off, raised to the proper height, and the stirrup bolts inserted. Those immediately adjacent to the towers were placed first, and a track laid as fast as the work progressed, upon which the more remote ones were run out. The number of double floor-beams is 450.

The six longitudinal trusses which divide the bridge into five passage ways have the following heights, measured from the top of the floor-beams: The two outside ones, 7½ feet, the four intervening ones, 15 feet 7½ inches between the floor and bottom of the top braces. Across the central opening is a system of light beams supporting the foot way; this foot way is 12 feet above the floor-beams. The outside divisions are 18¾ feet wide in the clear, covered with plank flooring, and designed for vehicles. The next two are 12½ feet wide, and will be used by passenger cars. The central opening—the foot path—is 15 feet 7 inches wide, and the elevation of the walk permits an unobstructed view of the surrounding country. As the foot passenger approaches the tower he ascends five or six steps, and to avoid the central shaft passes through the arches on a flooring laid on the beams over the car tracks. The cars and vehicle ways go through the arches side by side.

To prevent horizontal vibrations and resist the force of the wind, there are wind braces placed beneath the floor-beams. These braces are large wire ropes, and are anchored at the four facing corners of the towers to eye-bolts set in the masonry. From the corners to which they are attached they pass diagonally across the floor-beams to the opposite side of the bridge, where they are secured. The longest ones reach about one-third way across. Similar braces are placed on the land spans. As a further precaution, and particularly to secure stability in the center of the span, where the braces are of little effect, the outside cables are drawn in a short distance toward the center.

To allow for expansion and contraction of the long trusses, expansion joints are inserted between the towers and anchorage and in the main span.

The total weight of the suspended superstructure, including cables, trusses, suspenders, braces, timber flooring, steel rails, etc., is 14,680 tons; and the transitory load is estimated at 3,100 tons, making the total weight of the bridge 17,780 tons.

We have now finished the bridge from anchorage to anchorage, and shall devote the remainder of our space to considering the approaches, stations, cars, moving cars, and financial statements.

The approach on the Brooklyn side is 900 feet long on the center line, and commences at street grade at Sands Street, rising 2·85 feet per 100 to the rear of the anchorage, where it is 60 feet above ground. It is crossed by several streets, and has one curve at about 200 feet from Sands Street. It is 100 feet wide throughout. All the streets are crossed by box or plate girders. The New York approach is 1,546 feet long, commencing at grade at Chatham Street, and rising 3·25 feet per 100 to the rear of the anchorage, where it is 68 feet above ground. It is 100 feet wide for about 500 feet of the distance, and 85 feet for the remainder. At Franklin Square is an opening measuring 210 feet on one side and 170 on the other, which is spanned by a truss bridge. The other streets are crossed by semicircular stone arches. The approaches are a series of arches resting on heavy piers with fronts entirely of granite. The cornice over the arches has a dentil course below, surmounted by a heavy projecting coping course. The cornice is surmounted by an ornamental granite parapet, 4 feet high. The arches in the approaches will be fitted up for warehouses, and in order to sustain great weight the floor-beams will be of steel and wrought iron.

Both the station buildings are constructed of iron. The viaduct to accommodate passengers at the Brooklyn end is about 600 feet long. Beginning at Sands Street it is 56 feet wide (the two passage ways for vehicles are at either side of the building) for 205 feet, of which 185 feet is roofed and inclosed on the sides. This forms a building, the ground floor of which is used by foot passengers, with the exception of a waiting room, 60 by 18 feet, on the left as we enter. The next floor is at a height of about 20 feet above Sands Street, and contains three lines of rails in the central space and two capacious passenger platforms, one at each side, and raised 2¼ feet above the rails. These platforms extend to some distance beyond the end of the building. The sides of the building from the main floor to the eaves of the roof are of ornamental cast-iron work and glass. The lantern framing is over the center of nearly the whole length of the building, and is 14 feet wide by 3 feet high. The car passengers enter the waiting room below, pass up wide stairs to the platform, and enter cars on the right track. Incoming passengers get off on the other side.

The New York station is 260 feet long by 52¼ feet wide; the height to peak of small roof at rear end is 52½ feet, at front end 61 feet. The general arrangement is very similar to that of the other station.

The twenty-four cars are like those now in use on the elevated roads of this city. They are 44 feet between couplings, 9½ feet wide from out to out, and will comfortably seat 48 passengers. In the middle of the car the seats are placed crosswise, leaving an aisle between; near the doorways they are placed along the sides.

The cars are moved by being attached to an endless rope operated by powerful engines situated beneath the Brooklyn approach. This steel wire rope, 1½ inches in diameter, passes over the bridge in the middle of the right railway track, and returns along the other. It is supported throughout its length on 490 pulleys, placed 22½ feet apart. Motion is communicated to the rope by winding it three times around a pair of grooved driving drums, placed facing each other. These drums are made of cast iron, 12 feet in diameter, and have faces 27½ inches and 26 inches across respectively.

The drums are revolved by means of a friction drum placed between them, and being five feet in diameter and 31½ inches across the face. This drum is mounted upon a shaft of hammered wrought iron 12 inches in diameter, and at each end of the shaft is a crank to which the engines are attached. By means of a clutch at each end of the shaft the engines can be worked alone or together. The engines have a variable cut-off, 48 inches stroke, 26 inches diameter of cylinders, and will work safely with 100 pounds of steam. The boiler house contains 4 boilers, and is placed in a separate building located to the right of the approach. From the driving drums the rope passes upward and over a grooved sheave 10 feet in diameter, and a loop is then passed around another sheave of the same size, mounted on a heavily loaded car moving on a steeply inclined plane, thus serving as a balance weight to draw the rope tightly. The returning part of the rope goes under a third sheave, then up over a summit sheave placed between the rails, and then out on the pulleys. The switching of the cars on this side is done by dummy engines.

Just before the New York station proper is reached, the rope is passed down over a summit sheave around return sheaves to the other track, up over another summit sheave and back to the Brooklyn side. Before leaving the New York side the rope passes over and then under two sheaves placed near together, thereby giving them motions in contrary directions. On the shafts of these sheaves are small grooved friction drums, which can be pressed by a lever against either sheave according to the direction of the revolution desired. Wound about these two drums is an auxiliary rope leading into the station. After the car has discharged its passengers, it is attached to this auxiliary rope, which takes it to the upper end of the station. The grade of the road is such that upon being released the car descends by gravity to its station at the other platform, where it meets the endless rope over the bridge.

The engineers are not prepared to make public the plan of the clutching device by which the cars will be attached to the rope. From end to end the bridge is lighted by arc electric lights, the dynamos and engines being under the Brooklyn approach.

On the 31st of last March the financial condition of the bridge was, briefly stated, as follows:

Cash received from New York	$4,871,900 00
" " " Brooklyn	9,423,692 73
" " " rents, interest, sale of material, etc.	391,463 93
Total	$14,687,057 66
There is still due from the city of New York	216,666 66
And from Brooklyn	483,333 34
Total cost of bridge	$15,387,057 66

Some of the principal items of cost up to March 1, were:

Engineering, salaries, etc.	$498,963 68
Office expenses	167,446 41
Timber and lumber	469,031 23
Construction	3,128,969 46
Labor	2,416,151 33
Machinery and tools	161,015 56
Land, damages, and buildings	3,780,988 94
Limestone	668,041 37
Cast steel cable wire	623,733 16
Granite	2,129,004 93

The names of the engineers who planned and so successfully executed this work are:

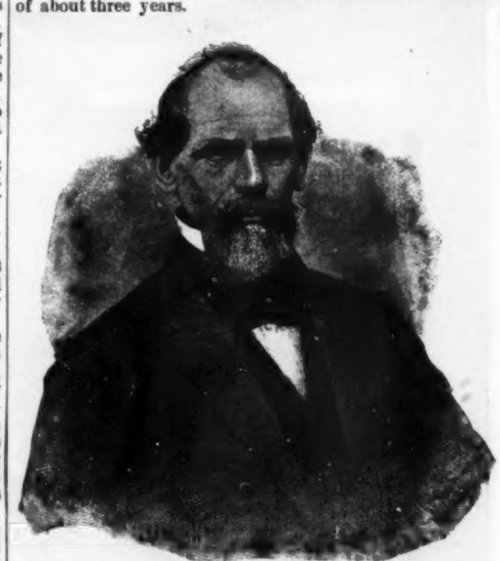
JOHN A. ROEBLING.
WASHINGTON A. ROEBLING.
C. C. MARTIN. W. H. PAINE.
F. COLLINGWOOD. G. W. MCNULTY.
S. R. PROBASCO. W. HILDENBRAND.
E. F. FARRINGTON.

JOHN A. ROEBLING, C.E.

THE subject of this sketch was born on June 12, 1806, in the city of Mülhausen, Prussia. He took the usual academical course, and completed his education as a civil engineer at the Royal Polytechnic School in Berlin. As a student his career is said to have been unusually brilliant.

Mr. Roebling's first practical experience in the profession he had selected was upon certain governmental works in Westphalia, three years being spent in that duty.

In 1831 Mr. Roebling came to the United States, and for several years devoted himself to the improving of a tract of land near Pittsburg, Pa., and to the attempted founding of a town. Tiring of this uncongenial class of work, he soon sought and obtained a position as assistant engineer on the slackwater navigation of the Beaver River, a tributary of the Ohio; from this work he was transferred to the Big Sandy and Beaver Canal, and later still was engaged in the construction of a feeder to the Pennsylvania Canal, from the upper portion of the Alleghany River. A survey for a route across the Alleghany Mountains, for the Pennsylvania State Railroad, between Harrisburg and Pittsburg, next occupied the time of the young engineer for the space of about three years.



JOHN A. ROEBLING.

Having completed the State surveys intrusted to his care, Mr. Roebling turned his attention to the manufacture of wire rope, an until then untried industry in the United States. He had been investigating this subject for some years previously, and as a result of this study he devised new and improved machinery for his first works, which were located near Pittsburg, Pa.

Probably his first application of wire cable to structural purposes was in 1844. At that time the wooden aqueduct carrying the Pennsylvania Canal across the Alleghany River became so unsafe as to require renewal; and Mr. Roebling designed and contracted for the erection of a new aqueduct, the trunk constructed of wood as before, but supported upon a pair of continuous wire cables, each seven inches in diameter, and forming in all seven spans of 162 feet each.

In 1844, while the aqueduct just mentioned was still under construction, the wooden bridge across the Monongahela at Pittsburg was destroyed by fire, and at once replaced by a suspension bridge from Mr. Roebling's design. This structure had eight spans of 188 feet each, and there were two cables, each 4½ inches in diameter.

In 1848 Mr. Roebling contracted for the erection of four suspension aqueducts for the Delaware & Hudson Canal Co., with dimensions as follows: Lackawaxen aqueduct, two spans of 115 feet each, and two seven-inch wire cables; Delaware, four spans of 134 feet each, two eight-inch cables; High Falls, one 145 foot span, two 8½-inch cables; Neversink, one 170 foot span, two 9½-inch cables. While engaged upon these contracts Mr. Roebling removed his manufactory of wire rope from Western Pennsylvania to Trenton, N. J., founding the establishment now so well known as Roebling's Sons.

As early as 1846 the problem of bridging the Niagara River for railroad purposes was being investigated by the subject of our sketch. It was at first proposed to haul the cars across by horses, no engine to pass over. Upon this basis, Mr. Roebling, in the year mentioned, offered to construct a railway suspension bridge, with one track, two carriageways and two footways for the sum of $180,000, but Col. Chas. Ellet, Jr., who was his competitor, obtained the contract for the erection of the first Niagara Suspension Bridge.

It was soon after determined by the railroad authorities to replace this first bridge by one adapted to the passage of engines as well as cars, and Mr. John A. Roebling having been appointed chief engineer, commenced operations in 1851, and in March, 1855, completed the work assigned him.

The span of this famous bridge is 825 feet, with the track at an elevation of 250 feet above the water in the Niagara River. The four cables each contain 3,539 No. 9 iron wires. The trusses introduced into this structure for stiffening purposes were the marked features in its construction. Many other departures from older methods were here used, notably the continuous wrapping of the cable with wire, as a substitute for iron bands or simple coils of wire. The machine used for this purpose was the invention of the builder of the bridge.

While the building of the Niagara bridge was in progress, Mr. Roebling designed a wire suspension bridge for the then projected Lexington & Southern Railroad, at its crossing of the Kentucky River. The span was 1,224 feet. The towers and anchorages were built and most of the wire delivered, when financial embarrassment caused the company to abandon the work. These same towers were recently utilized by Chas Shaler Smith, C.E., in the erection of the truss railroad bridge now spanning the Kentucky River at that point.

In 1856 Mr. Roebling commenced laying the foundations of the Cincinnati and Covington Suspension Bridge across the Ohio River, after having as early as 1846 made plans for a bridge at the same point; his first design differing from the one finally put into execution in having two spans, with a tower in the middle of the stream. The financial crash of 1857, and then the rebellion of 1861, delayed work upon this structure until 1863, when Mr. R. resumed operations and finished the bridge in 1867.

The principal dimensions of the Cincinnati and Covington bridge are as follows: Main span between centers of towers, 1,057 feet; side spans, from center of towers to abutments, 281 feet; Cincinnati approach, 341 feet; Covington approach, 292 feet; total length of bridge, 2,252 feet. The two cables are each 12½ inches in diameter, and each one contains 5,200 No. 9 iron wires. The weight of each span between the towers is 1,500 tons, and the ultimate strength of each cable is 4,212 tons. The roadway is 20 feet wide between the cables, with two footways of seven feet each outside the line of cables.

Between 1858 and 1860 the Alleghany Suspension Bridge was built at Pittsburg, with a total length of 1,030 feet, divided into two spans of 344 feet each, and two side spans of 171 feet each. The floor is forty feet wide. There are four cables, two seven inches in diameter and two four inches in diameter. The towers are cast-iron.

The last and crowning professional work of Mr. Roebling's life was the design and commencement of work upon the already celebrated bridge now spanning the East River, and uniting the cities of New York and Brooklyn. It was upon this work, and in the direct line of professional duty, that Mr. Roebling met with the accident that cost him his life. His right leg was crushed by the shock of a ferry boat against the fender piles on which he was standing, directing some of his workmen, and his death followed on July 22, 1869. His name will ever be inseparably connected with the work upon which he was last engaged, and his memory will be honored with a prouder monument than usually falls to mortal lot.—*Engineering News.*

WILLIAM MASON.

WILLIAM MASON, the distinguished locomotive builder, died on the afternoon of May 21 at his home in Taunton, Mass., of pneumonia, at the age of 76. He was born in Mystic, Conn., and with nothing but his hands and genius made for himself a name and a fortune. No one in this country has done so much to develop and perfect the American locomotive as Mr. Mason. He was a wonderfully ingenious man, and combined with his ingenuity a high order of the artistic sense, so that his work was always most exquisitely designed. Just as architecture has been spoken of as "frozen music," so it might be said of Mr. Mason's locomotives that they are melodies cast and wrought in metal.

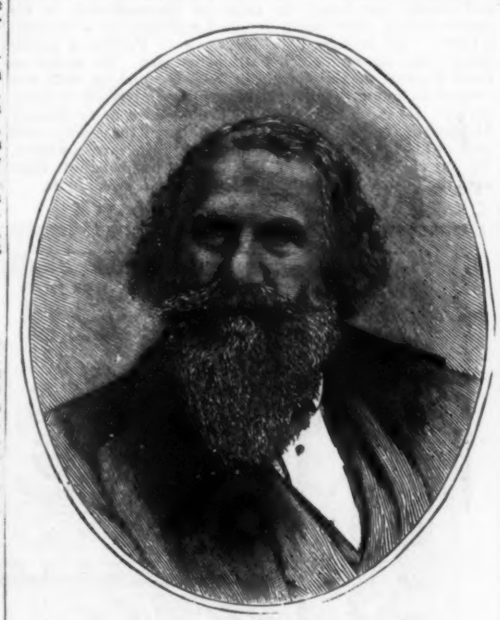
Of the work that he did during his lifetime, no full account has ever been given. We are fortunate in having a verbatim report of a conversation had with him some months before his death, in which he related much of his experience and recounted what he had done during his professional and business career. Probably no better idea can be given of his life and of his work than to quote freely from this report.

In the conversation referred to he said:

"I learned my trade in Canterbury, Conn., but I came from Killingly. I went up into New York State one season and often was at Utica. Old Captain Baker was making cotton sheeting, etc., and he heard they were making cotton diapers in the vicinity where I was, and he wrote up to see if I couldn't learn how to make cotton diapers and put the machinery into his mill. I found there were none woven on looms, but they were done by hand. I studied the matter a little and made some looms for him to make such goods. I built them at Canterbury, where I was learning my trade. The machine shop was under the cotton factory—they were all under the cotton factories in the old days. After I got through with this job I was fooling about for some time, painting portraits, making fiddles, and one thing and another. Finally they sent for me to come up to Killingly. They were trying there to make the ring frame. Somebody had got up a ring frame, but it was a miserably poor thing. It would not go at all. I looked it over while I was there and watched it. Two or three men tried it. The man who invented it could not make it go, but they tried it there till they created such a prejudice against it that nobody would have it in the neighborhood. I made up my mind that there was something in it if it was only brought out right, and I took the shop and went into it, and I brought out the frame. I have since been called the father of it. I had hard work to introduce it, about as hard work as I had to introduce the double-truck locomotive. I was twenty-five years old then. There was great prejudice against the ring frame. The only way that I could introduce it was to go to a man who wanted some spinning done and say to him, 'I will make you a frame to do so much more spinning. I will put it into your mill and start it up and you can run it. If you do not like it, I will take it away and it shall not cost you anything.' I never had to take one back. I manufactured quite a number of them in the old shop, until it became known what it was. I then went down to Taunton and brought my machines down. I went there to run a shop of Crocker & Richmond. I was there a year when they failed, and I never got a cent of salary from them. They put the shop into the hands of Leach & Keith to run. I took charge of that, and got up the self-acting mule there. Very soon they failed, and then I bought them out, or rather some one else bought them out for me. I remained there three years and then built the place I am at now.

"The cotton machinery I have made has gone all over the United States. I went down to Petersburg, Va., when I was working for Leach & Keith, and designed a mill, and staked it out, and took a contract for the machinery for that firm. I went into business in Taunton in 1842, and commenced building locomotives in 1852. The first that I built went out to Indiana. I afterward built a number of engines with Boardman boilers. The first were for the Providence & Worcester Railroad, and I built some others for the Illinois Central. I built them for other parties. They were not a success, but that was not my fault. I went according to orders. The most popular locomotives at that time in this country were those built by Rogers. They were the best there were. The first idea I had about improving the engine was to put the cylinders down level. As it was built at that time the locomotive looked like a grasshopper. the old Baldwin engines were worse in this respect than the Rogers. The cylinders were all put up so as to be above the truck. Another thing on the old-fashioned engines was that if anything was the matter with the frame, at either end, you had to take the whole engine down. I was the first to make the front end of the frame separate from the back end, so that the one part could be removed without removing the other part. I have improved it somewhat since. I made the driving-wheels with hollow spokes and hollow rim. I also got up a set of truck wheels about that time. The plate wheels which were put under an ordinary engine truck looked like cheeses. I wanted my truck wheels to have some relation in appearance to the drivers. Therefore, I never have had a plate wheel under any engine that I have built. Sometimes they were put under after the first wheels were worn out. I also put the counterbalance into the rim of the wheel by pouring lead into it, and now have that to perfection. I have a rim that will hold enough lead to counterbalance the revolving and reciprocating parts. The lead is poured into the hollow rim.

"Rogers used the link motion in this country before I did; but he hung it from below. I hung my link above the center, and had the suspension link the same length as the rocker arm, so that the link block would not slip at all. At that time I was trying to prevent the slipping of the block, but have found since that the slip is of very little consequence, because, if it slides at all, it is just as well to slide six inches as two inches, so far as the wear is concerned. A



WILLIAM MASON.

little motion of that kind sometimes wears more than a long motion.

"In staying the crown sheets I found that the bolts that go up through the crown bars were riveted, and I found that they were so long they would leak. I thought the matter over and got up the plan which I am now using. Everybody adopted it. They are now put on with a cone at the bottom.

"I designed the arrangement of wedges in the jaws for locomotive driving boxes. I put a shoe next to the box and a wedge behind the shoe and between it and the frame, so that the wedge was out of sight. Rogers adopted that plan. After a while I found that it was not a good way to have a wedge on both sides; that the men on the road were careless and would shove one up too much, so I made one side of the frame straight, and put the shoe on it also straight, and put a wedge on one side only. I now make both jaws straight. Then I put the wedge behind the shoe. Both the wedge and the shoe are tapered. The two together make a straight surface for the box.

"In the full-sized engines I have built I have generally given seven-eighths lap, but on freight engines, which work slow, I make it three-quarters. I give a little lead at full stroke with the link. You do not want too much, for in time you get more than you need. Lap and lead in effect are all the same thing. The only thing that made locomotives run quick was the lap. The original slide valve had no lap, and, of course, they could not get rid of the steam, because it would not exhaust. The lap was what gave the lead to the exhaust. The lead has precisely the same effect on the exhaust as the original lap would have. That is the whole secret of the lead. They used to think that they must have a lead or else the engine would not run smart. It was not because it let the steam in quicker, but because it let it out quicker.

"Compression is a valuable thing in a locomotive. The steam you catch in the cylinder there is not lost. It enters as a cushion to stop your piston, whereas if you did not have that your engine would go to pieces very quick. It is all nonsense to say that the steam which fills the clearance spaces and the steam ports is lost. About the time that I commenced to build locomotives they were all trying to get rid of the compression. You see, it answers as a cushion, and leaves the passages all full at high pressure, so that you do not need any lead. Sometimes you get more pressure there than you have in the steam chest, and on that account you do not need any lead. In slow running engines you do not need so much lap and lead, because you have more time to exhaust and you hold your steam longer. For that reason, of late years, when I came to reflect, I have given little if any lead on the link motion, because in starting a train they want to hold on to the steam as long as they can. As soon as they begin to go quicker, they begin to cut off, and then they begin to have lead.

"I built quite a number of engines with perforated supply pipes and without a dome, excepting a small one for the whistle and safety valve. The plan worked very well.

"I am now making the top of the outside shell of the firebox of boilers for double truck engines flat, and staying the crown sheets direct to the flattened portion with straight stay bolts. It is better than the common way of staying the crown sheet.

"I am also overhauling the designs of my ordinary American locomotive. I began some time ago and made new patterns for wheels, etc., and am making the engine generally heavier and stronger, larger bearings, etc. I am going to make the bearings for the driving wheels 8 inches in diameter. I have been thinking of getting up a slab frame for the 18-inch cylinder engines. I have thought of making it a slab frame alongside the fire box. I could then get 5 inches more width in the fire box, but would have to put the springs below the frames.

"I do not believe that there will be as great an increase in the size of locomotives during the next ten years as there has been during the past ten years. I think they are making a mistake in building those large engines and in making such big wheels. I saw some on the Pennsylvania road, which, I think, have 6½ or 7 foot driving wheels.

"My principal business has been cotton machinery. At the time that I commenced there was a little slackness in cotton machinery, and for that reason I took hold of locomotives. My locomotive business now is the meanest part of it and always was. I took an interest in it, and tell my friends that I got up locomotives for fun, but that it was the most expensive fun I ever had. I made just enough money from my cotton machinery to pay for my losses on locomotives. I am now doing a good deal of printing-press work, which is done by contract. I have nothing to do with the selling of them, and wish I could build locomotives in the same way. I now employ about a thousand men in my shop; sometimes more, sometimes less.

"A great many men who start in the machine business fail. My own idea of a machine shop is that the money made out of it is always made because the mechanical manager of it is sharper than other people. If he is not, he will not make much money. I never knew a machine shop to make money, the head of which was not a skillful mechanic. To manage a machine shop a mechanical man with business qualifications is needed. Generally, the successful shops are those that start in a small way under some man who has brains and takes a fancy to machinery and works it up."

A striking illustration of the "resourcefulness" of Mr. Mason was related by Mr. Coleman Sellers, who, on hearing of the death of Mr. Mason, made the following statements:

"In all the early cotton mills, the translation of motion from the engine or water wheel to the line shafting was effected by means of a vertical shaft transmitting its power to the horizontal shaft, through a system of beveled wheels. The step under the vertical shaft was always a source of very great trouble. Regardless of all that had been known of friction being dependent on weight and independent of surface, the custom then was to make very small steps under very large shafts and presumably to diminish the amount of friction. No upright shaft in any mill had been known to run cool, and it was a source of continual trouble. Mr. Mason, in thinking of how the difficulty might be overcome, conceived the idea of placing at the foot of the upright a disk of metal, of brass or iron, so large in diameter that the weight of the shaft, and the machinery upon that shaft, pressing upon this disk of metal, should not exert more than 50 to 100 lb. pressure per square inch of surface, he arguing that if the pressure per square inch was diminished upon the step by an increase of surface, the difficulty would be overcome, provided there was not a too great velocity of the surfaces in contact. Having had constant trouble with one particular upright in a mill in New England, he prepared for that mill such a step. The disk which was at the bottom of the upright was, say 14 inches in diameter. It rested upon a stationary plate which was made to rock so as to accommodate itself to the overfall of the upper disk. The disk was crossed by two diametrically right-angled grooves, each half an inch wide. Through the center of the lower block was drilled a hole with lateral holes passing into that to permit oil to flow in and pass up to the center of the disk. The lower disk was then squared on the outside and supported in a large cast iron box, which would contain several bucketfuls of oil, burying these disks under the surface of the oil. Above this arrangement was placed a pillow block to hold the shaft in its position of rotation. The machinery looked so cumbersome that the proprietors of the mill refused, Mr. Mason said, to put it in, it was so entirely contrary to their ideas of what should be used in such a case. After the usual period of existence of the old-fashioned steps, the inevitable break-down came. It was then decided to place this new step of Mr. Mason's in and try it temporarily. It was put into place and the mill started, when to their astonishment they found that the gate of the water-wheel need not be opened as wide as formerly—in other words, that very much less power was being consumed in friction than before. This step of Mr. Mason's, which he himself seemed to have given little thought to, afterward was brought into the States further south and introduced into all the mills about Philadelphia; and I have seen steps that have been running under those uprights of the Gloucester mills for sixteen years taken out, and the tool marks upon the disks were not even erased, so little had been the friction; the theory of the thing being that the oil is continually drawn up through the center and spread over the disk by the centrifugal force of the revolution, and that, in point of fact, the two disks never touched each other, but worked upon a naturally formed bearing of oil."

The mechanical ingenuity of Mr. Mason and his skill in designing and constructing machinery were of such a high order, and they approximated so near to the artistic faculty, as to be almost identical with it. In the work he designed he observed the principle which Ruskin laid down with reference to buildings, that "in the main we require of them, as from men, two kinds of goodness: first, the doing their practical duty well; then that they be graceful and pleasing in doing it," and it may be said of him, as the same writer said of builders, that what we have to admire is "the knowledge of all difficulties to be met, and of all means of meeting them, and the quick and true fancy or invention of the modes of applying the means to the end." The locomotives designed and built by Mr. Mason indicate

at once that he understood thoroughly the practical purpose they had to serve, and the difficulties to be met, and their marvelous grace and beauty showed him to be a master of the means of meeting those difficulties and effecting his purposes. The work which he did always bore the indication of his consummate skill in the adaptation of the simplest and most appropriate means to the ends arrived at.

His shops, the roof of his foundry, the tools and appliances used in the shops, all bore the indication of his skill and genius. Everything that he touched at once assumed a symmetry entirely consistent with the purposes it was intended to serve. The impression produced by his locomotives always was, that they could not have been otherwise—that they were the result of some natural process of growth or development, and the observer was apt to go away from them, as he would from a person dressed in entirely good taste, without any distinct impression how the locomotive was constructed.

Mr. Mason, under what to strangers sometimes appeared an austere manner, possessed a great deal of kind-heartedness. The very qualifications which enabled him to succeed as he did, also indicated to him the deficiencies of those who aimed at success and sought his aid. With inefficiency he had little sympathy, but to persons of ability he would offer assistance in a sort of shy, deferential way, as though he considered it a favor for them to accept his help.

He was very fond of the companionship of younger men than himself who were congenial, and took an interest in a wide range of subjects outside of his own occupation. He was especially interested in art, and was a severe critic, with little patience with the careless work now so common among a class of young artists. If instead of devoting himself to engineering and mechanics, he had chosen the career of an artist, his success would doubtless have been very great.

Mr. Mason has left a large fortune. His wife died a few years ago. Two sons and a daughter survive him.—*Railroad Gazette.*

THE LATE DR. WILLIAM CHAMBERS.

THE senior but surviving brother and partner in the Edinburgh publishing house of W. & R. Chambers has died, of natural old age, within a few days of the time at which he would have been raised to the rank of a baronet, by the well-

WILLIAM CHAMBERS, LL.D.

deserved favor of the Queen, upon the occasion of reopening St. Giles' Church, which has been restored by the aid of his munificent gift.

The venerable founder of *Chambers's Edinburgh Journal*, and the producer, during more than half a century, of an immense amount of wholesome, pleasing, and useful popular literature at the cheapest price, has been a very great benefactor to the whole nation. The personal history of William & Robert Chambers, the two brothers, is very remarkable. Its beginning shows how a couple of poor boys, coming up from their native town of Peebles to the Scottish capital, really managed to do, for a time, what the worldly-wise wits and critics of the *Edinburgh Review*, as Sydney Smith said on their behalf, parodying a line of the first Eclogue of Virgil, pretended to do: "We cultivate literature on a little oatmeal."

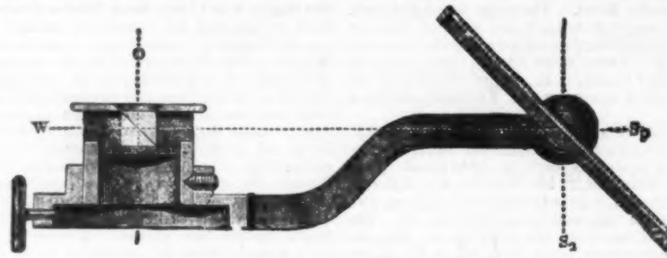
They actually contrived, in the early days of their laborious and studious poverty, before they kept the street bookstall on Leith Wall, to live at a cost of about threepence-halfpenny for each young man's daily food. They gathered much learning, as well as business knowledge; and Robert Chambers, more especially, made himself an accomplished literary scholar, mastering a considerable extent of Scottish historical and antiquarian lore, and of geological science.

William Chambers devoted himself personally to the bookselling and printing trade, while his brother at first wrote or edited some of their numerous publications. They began, in this way, with a magazine called the *Kaleidoscope*, which was not successful. Then Robert Chambers compiled a series of local and biographical anecdotes to illustrate the Waverley Novels: and this example led to the "Traditions of Edinburgh," and a larger work, "The Book of Scotland," by William Chambers, published in 1830, giving an account of the distinctive laws, institutions, and usages of that part of the United Kingdom. "The Gazetteer of Scotland," a work of great labor, was the joint production of the two brothers. In 1832, the Society for the Diffusion of Useful Knowledge set up the *Penny Magazine*, with the aid of the late Mr. Charles Knight as London publisher, and furnishing good illustrations to the good reading matter. Messrs. W. & R. Chambers got the start of them by six weeks, coming out with the *Edinburgh Journal*, price three-halfpence, but with no illustrative engravings. There were not, indeed, at Edinburgh in those days the artists and engravers who could have produced anything like the *Penny Magazine*, if Messrs. Chambers could have ventured upon the cost; but the *Edinburgh Journal* had the merit of happily mingling sound instruction with intellectual and rational entertainment. Its circulation rose in a very few weeks to upward of 50,000 copies, and became at once an assured success. The brothers followed this up by next bringing out in cheap parts and weekly numbers the "Information for the People," and their "Encyclopedia of English Literature," enlisting several able pens in the production of these treatises. We have also to mention their "Educational Course," their cheap "Editions of Standard English Works," their ancient and modern "Grammars," "Dictionaries," "Histories," and miscellaneous papers reprinted from their *Journal* with additions.

William Chambers published also a "History of Peeblesshire," a volume of "Sketches in America," a "Memoir" of his brother Robert, who died some ten years since, a volume of "Autobiographical Sketches," and a novel entitled "Alice Gilroy." The cyclopedia in ten volumes which bears the name of Chambers was edited by the two brothers jointly, assisted by learned contributors in special subjects. Dr. Robert Chambers died in 1871. About the year 1850 Mr. William Chambers, having made a fortune by his industry and ability, purchased the estate of Glenmoriston, in his native county, thenceforth to take local rank as a Scottish "laird." He bestowed on the town of Peebles a public library and museum erected at his own cost. He served as Lord Provost of Edinburgh in 1865-66, and in 1872 was created an honorary doctor of laws of the University of Edinburgh. He was a magistrate for Peeblesshire, and a Deputy Lieutenant for Edinburgh. He completed the eighty third year of his age on April 16 of this year. He leaves a widow, but no children; a son of Dr. Robert Chambers now manages the business of the firm.—*Illustrated London News.*

ABBE'S CAMERA LUCIDA.

THE glass cube (consisting of two prisms, with a hypothenuse surface silvered, and having a small hole in the center) is at W, the reflecting mirror at Sp, the eye at O. The rays from the paper come in the direction S_2, and are reflected first at the mirror, and a second time by the silvered prism to O, while the object is seen through the small hole in the silvered surface. Dr. Abbe states that the small cube should be "so adjusted that the hole [in the silver film between the two prisms forming the cube] exactly coincides with the 'eye-point' of a Zeiss No. 2 ocular," which is secured by the



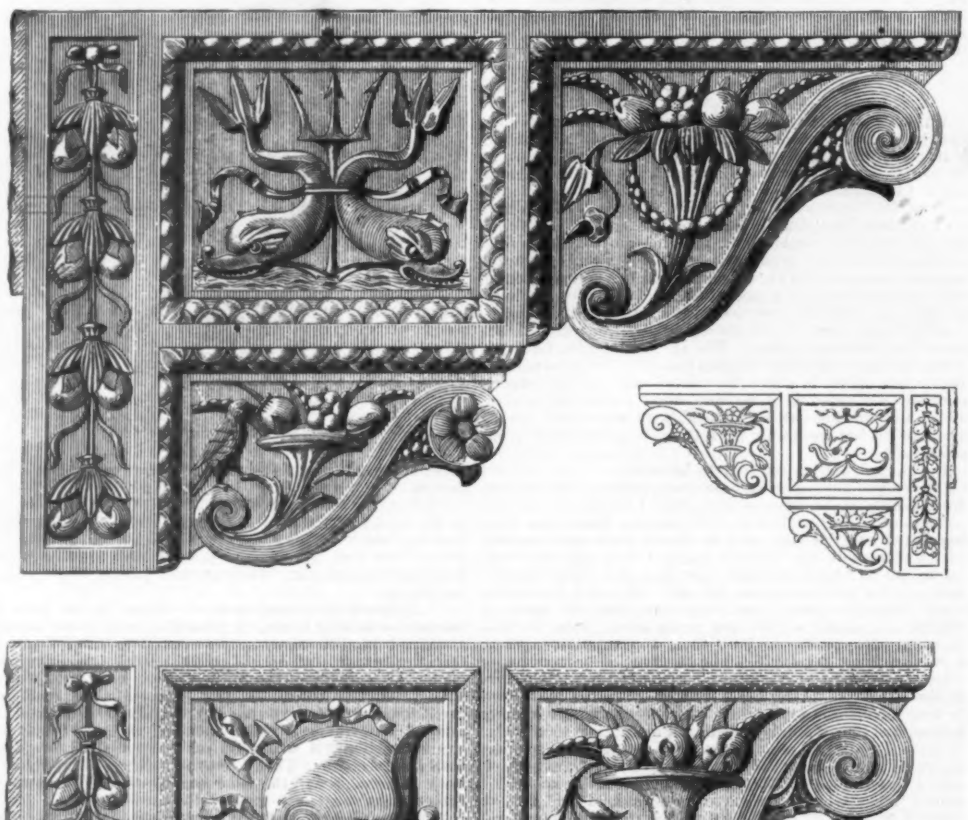
IMPROVED CAMERA LUCIDA.

mounting; and further explains, "that the camera is attached to a particular eyepiece, and is not, as usual, made adjustable for those of different power, arises from the fact that in the higher Huyghenian eyepieces the eye-point lies too near the eye-lens."—*Jour. Roy. Micr. Soc.*

A PRACTICAL PROTECTION AGAINST RUST.

IF 10 per cent. of burnt magnesia, or even baryta or strontia, is mixed cold with ordinary linseed oil paint, and then enough mineral oil to envelop the alkaline earth, the free acid of the paint will be neutralized, while the iron will be protected by the permanent alkaline action of the paint.

To protect iron from rust while in the earth, it may be painted with a mixture of 100 parts of resin (colophony), 25 parts of gutta-percha, and 50 parts of paraffine, to which 20 parts of magnesia and some mineral oil have been added. Paint for machinery contains 20 or 30 per cent. of magnesia, or burnt dolomite, and to prevent its drying up some vaseline is added. Paper or cloth used to wrap bright ironware should be coated on one side with the above mixture, and on the other with a bichromated gelatine solution to make it water-tight.—*Neueste Erfind.*



CONSOLES IN ISTRIAN LIMESTONE FROM VENICE, NOW IN THE MUSEUM FOR ART AND INDUSTRY, HAMBURG.

THE PURIFICATION OF FEED-WATER.

IN the examination of the properties of water with a view to its use for supplying boilers, it has been suggested that due attention should be given to its influence upon the boiler and its liability to form solid deposits. The injury which boiler metal receives in such cases differs essentially in its nature from that which is produced on the external surface of the boiler by the action of the sulphurous acid and superfluous oxygen in the smoke gases, together with the presence of damp. The internal surfaces of boilers, on the other hand, suffer from the oxygen and carbonic acid in the water which is in contact with them. The simultaneous presence of chloride of magnesium tends to intensify the noxious influence of the oxygen. It is, of course, well known that free acids, metallic salts of acid reaction, and fatty substances should not be found in water used for the purpose indicated.

This theory has recently been propounded in detail by Dr. Fischer in the official organ of the German Boiler Inspecting Association, and he quotes an instance in which considerable froth was found to be produced when the water was heated. An examination of the spring water and condensed water used failed to establish traces of any importance either of magnesia or fatty substances. There was a scarcity of matters capable of forming incrustation, but a somewhat large quantity of organic substances was discovered which were easily oxidized, and to which the frothing was attributed. At last it was found that the spring from which part of the water supply was obtained was in the vicinity of a cesspool, whence the organic substances must have been derived.

It is remarked that incrustations are caused by the presence in the feed-water of sulphate and carbonate of lime, and carbonate of magnesium. The following methods have from time to time been adopted for obviating these injurious effects by appliances within the boiler itself: (1) By electricity and zinc linings. Dr. Fischer expresses himself unfavorably as to the efficacy of these systems. (2) By slime-catching appliances and boiler linings. These appliances serve to remove the froth or scum and remove the liability of the slime to be burnt into the fire-plate. They cannot, it is remarked, prevent the formation of solid incrustations. (3) Shreds of metal, clay, etc. Various descriptions of powders—such as powdered heavy spar and talc—are referred to, but they are considered by Dr. Fischer to be more or less injurious in their operation. (4) Greasing or tarring the sides of the boiler, the importance of which, it is remarked, scarcely requires detailed proof. (5) Tanning materials, which have been used since 1839, although attempts have lately been made to introduce the application of this principle as a novelty. (6) Precipitations in the boiler. Various chemical compositions have been patented for carrying out this principle.

In conclusion, Dr. Fischer remarks that all the methods referred to are ineffective, if not positively injurious. Under the most favorable circumstances they give powdery deposits, which are apt to be quite as troublesome as solid crusts. A caution is given against the use of specifics for preventing incrustations, which, it is remarked, are often introduced by speculators, to sell to credulous boiler owners.

For the purification of feed-water—which is specially necessary with tubular boilers—it is recommended that any measures with that intention should be taken before the water enters the boiler. Whether milk of lime, soda, or other methods are used, is a question dependent upon an analysis of the feed-water itself for its definite solution.

PANCLASTIC: A NEW EXPLOSIVE.

PANCLASTIC (break-all) is the classical name given by E. Turpin, of Paris, to a new explosive that consists of carbon disulphide and hyponitric acid, the latter made by heating acetate of lead. The mixture can be exploded by fulminate of mercury or gunpowder. It will not explode by percussions alone, nor when heated to 200° C. (392° Fahr.). The most powerful effects are obtained from equal parts of each.

The mixture burns, when not confined, with a brilliant white light, and can be used for illumination (*selenophanite*, or moonshine). For this use it is better to keep the liquids separate and feed them through capillary tubes to a dish that serves as a burner and which must be properly cooled.

The illuminating power of the mixture is still further increased by dissolving some phosphorus in the disulphide (*heliophanite*, or sunshine).

The new explosive is used to fill shells and torpedoes. Reports concerning experiments made with it at Cherbourg indicate that its fearful force far exceeds that of dynamite.

Hitherto most people have desisted from the use of liquid explosives on account of the difficulty of transporting and handling them, and it does not seem probable that the liquid "panclastic," which is evidently a very dangerous liquid, is destined to compete successfully with nitro-glycerine explosives.—*Polytechnisches Notizblatt.*

[Although not so stated, it is probable that the light produced can be used for photography, like the Sell lamp, in which nitric oxide and carbon disulphide were used. It is not safe enough for general use.—ED.]

USE OF LIQUEFIED GASES.

IN Krupp's establishment compressed carbonic acid is used for the manufacture of ice and of seltzer water. Dr. Raydt has taken out patents for drawing beer under a pressure which is produced by liquid carbonic acid. Major Witte has provided the steam fire engines of Berlin with pipes for the discharge of compressed carbonic acid into the steam chamber. When the engine starts from the station the boiler is heated; on arriving at the fire the carbonic acid is first employed as a motor, then the gas and the steam work together, and finally steam alone is used. By this arrangement the engine is brought into action four or five minutes sooner than would be otherwise possible. The consumption of the liquid gas is about 8 kilogrammes; twice the amount should be taken, and in two receptacles, to allow for the portion which congeals in cooling.—*Rev. Scientif.*

IGNITION OF EXPLOSIVE MIXTURES OF GASES.

MALLARD AND CHATELIER's experiments, as described in the Chemical Society of Paris, go to show that mixtures of hydrogen, carbonic oxide, marsh gas, and air ignite at temperatures of from 530° to 700° C. (986° to 1,292° Fahr.). The mixtures could be exploded by red hot iron, in contradiction to Davy's assumption that a temperature of at least 1,000° C. (1,832° Fahr.) was needed. But the heated and rarefied gas must not be allowed to flow away, and the action must last for five or six seconds.

BUNTE'S APPARATUS FOR DETERMINATION OF FURNACE GASES.

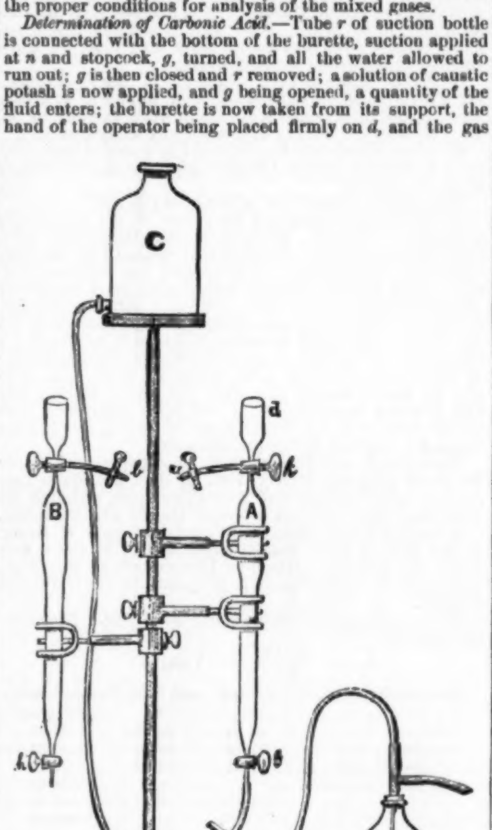
BY means of this apparatus a ready and sufficiently accurate separation and estimation of oxygen, hydrogen, carbonic acid, carbonic oxide, and nitrogen may be effected in a comparatively short space of time, thereby supplying to practical men a long-felt want in the determination of furnace gases, and enabling an operator with even a small amount of manipulative skill to ascertain the precise condition of the gaseous contents of the furnaces under his control.

DESCRIPTION OF THE APPARATUS AND DIRECTIONS FOR USE.

A and B are two burettes fitted with three-way stopcocks, and each graduated in fifths of a cubic centimeter, and capable of holding about 110 c. c.; C, a one-gallon tabulated bottle, serving as a water reservoir; D, a suction bottle used for rarefying the gas subsequent to the introduction of reagents.

Burette A is first filled with water up to stopcock by connection with C, funnel *d* being also nearly filled. C is then disconnected from A and connection made between A and D; the gas to be examined is now allowed to flow in at *a*, the water flowing from A to D until nearly empty. Connection is now re-established with C, and water allowed to enter until the bottom graduation is reached; the stopcock, *k*, is now carefully turned in order to allow a portion of the gas (which of course is under pressure) to escape through the water in *d*, until there remains exactly 100 c. c. of gas at the normal atmospheric pressure. The apparatus is now under the proper conditions for analysis of the mixed gases.

Determination of Carbonic Acid.—Tube *r* of suction bottle is connected with the bottom of the burette, suction applied at *n* and stopcock, *g*, turned, and all the water allowed to run out; *g* is then closed and *r* removed; a solution of caustic potash is now applied, and *g* being opened, a quantity of the fluid enters; the burette is now taken from its support, the hand of the operator being placed firmly on *d*, and the gas



APPARATUS TO DETERMINE FURNACE GASES.

is well shaken up with the liquid, this operation being again performed if absorption is found not to be complete. When this is effected, the stopcock at *k* is opened and water allowed to flow down until the normal atmospheric pressure is reached, indicated of course by the water ceasing to flow. The amount absorbed by the caustic potash is now read off = percentage of CO_2.

Determination of Oxygen.—The caustic potash solution is drawn off by means of the suction tube, and an alkaline solution of pyrogallic acid is applied in a similar manner as in estimation of CO_2; if oxygen be present, the solution becomes immediately black and the diminution in volume after shaking as before, and reducing to normal pressure, gives the percentage of oxygen.

Determination of Carbonic Oxide.—If oxygen has been proved to be present, carbonic oxide will most likely be absent, unless the gases have been brought together at a temperature insufficient to promote their combination.

In order to effect the estimation of carbonic oxide by absorption it is necessary to remove every trace of the alkaline pyrogallate solution by the use of the funnel, *d*, and the suction bottle; this done, a concentrated solution of cuprous chloride in hydrochloric acid is applied to the bottom of the burette as before; when absorption is complete, the cuprous chloride is drawn off, the tube washed, and treated with a solution of caustic potash, for the purpose of absorbing any hydrochloric acid vapor which may have been liberated in the reaction; after bringing to correct pressure, the reading shows percentage of carbonic oxide.

Carbonic oxide and hydrogen are, however, generally estimated by combustion, as follows: The gas is allowed to mix with atmospheric air by turning the cock, *k*, and momentarily releasing the pinch-tap, the water being permitted to flow out at *g*; normal pressure is then re-established by means of the funnel, *d*, and a reading taken. Connection is now made between *a* and *b*, uniting the two by means of a piece of hard glass combustion tubing containing a small coil of palladium wire. Burette B is now filled with water by connection with C. The palladium wire in the tube is brought to a red heat by means of a Bunsen burner, and the gas is caused to pass from A over the heated tube into B by opening *h* and *g*, connecting the reservoir water supply, C, with bottom of burette, A. When all the gas has passed over the operation is reversed, the gas being again collected in A. It is allowed to stand until the normal temperature is attained, adjusted for pressure, and read off. It might perhaps be considered advisable to notice here what has taken place in the combustion. The gases remaining in the mixture are hydrogen, carbonic oxide, and nitrogen; by the admixture of air, and passage over the red hot palladium coil, the oxygen of the air combines with the carbonic oxide (CO) to form carbonic anhydride (CO_2), and with the hydrogen to form water, the nitrogen of course remaining unacted upon. If the gas under examination consist entirely of hydrogen and nitrogen, it is obvious that the diminution in bulk multiplied by two-thirds gives at once the percentage of the former gas; *e. g.*, supposing there to be present 10 c. c. of hydrogen and 8 c. c. of nitrogen, and 22 c. c. of air have been admitted, the whole therefore measuring 40 c. c.; after combustion the measurement of the gas is found to be 25 c. c., showing loss in bulk of 15 c. c., which diminution is due to the combination of 10 volumes of hydrogen with oxygen 5 volumes, to form water 15 volumes (which latter occupies no appreciable space and may therefore be neglected), consequently $15 \times \frac{2}{3} = 10$ c. c. = vol. of hydrogen.

If carbonic oxide, hydrogen, and nitrogen be present, the calculation is still almost as simple. Supposing, for example, that the following mixture be contained in the burette:

Carbonic oxide	10 c. c.
Nitrogen	12 "
Hydrogen	8 "

50 c. c. of air are admitted, the whole measuring 80 c. c.; after combustion it is found that measurement is reduced to $80 - 63 = 17$ c. c.; the 63 c. c. of gases being now submitted to the action of caustic potash solution in the usual manner, the carbonic anhydride produced in the reaction is thereby absorbed, and a further diminution of 10 c. c. observed, which indicates the percentage of carbonic oxide present, since for every volume of carbonic oxide burnt an equal volume of carbonic anhydride is formed; and since also that this 10 c. c. of CO must have consumed half its volume or 5 c. c. of oxygen, we obtain—

$$(17 - 5) \times \tfrac{2}{3} = 8 \text{ c. c. of hydrogen,}$$

—nitrogen being then calculated by difference.—*Chemical News.*

AN AMMONIACAL LIQUOR TEST.

DR. KNUBLAUCH, Chemist to the Cologne Gas Works, proposes the following as a reliable method of testing ammoniacal liquor, giving results free from the errors inherent to specific gravity apparatus. The test tube is shown in the

annexed illustration. One hundred cubic centimeters of the liquor to be tested must first be diluted by the addition of distilled water to exactly half a liter in bulk and the whole thoroughly shaken. A stoppered flask is to be about two-thirds filled with this quintuple dilution, and a piece of quicklime (about 5 grammes per 100 cubic centimeters) added. The mixture then stands for an hour, with repeated shakings. The liquid is afterward filtered, the first thick portion being allowed to run away. Then 50 cubic centimeters of the filtrate with the normal sulphuric acid, colored with some rosaline-acid solution, are put into the test-tube until it is filled to the mark, M. A progressive yellow coloration begins, and gives the percentage of ammonia by direct reading from the graduations on the cylinder. The principle of this apparatus, which is made with the solutions complete by Herr Leybold, of Schildgasse, Cologne, depends upon the absorption of sulphuric acid of known strength by the lime contained in solution. It is practically a method of determining the alkaline constituents of a weak solution by difference. The construction of the tube is in accordance with this principle, for the smaller upper portion from 0 to M contains 6·33 cubic centimeters for the lime in solution, and every following cubic meter from 0 downward represents 0·1 per cent. of ammonia; so that 0·5 cubic centimeter on the cylinder represents 0·05 per cent. of ammonia, 1·0 centimeter equals 0·1 per cent., and so on. In comparison with exhaustive analyses by the usual methods, Dr. Knublauch has found this apparatus correct within some hundredths of a per cent.

DISTILLATION AND SUBLIMATION IN VACUO.

A. SCHULLER has made a number of distillations in the vacuum produced with his own mercury pump, with the following results:

1. The degree of rarefaction attainable with the air pump is affected not merely by the mercurial vapors, but also by the lubricators employed and the phosphoric acid used to dry it, as these contain constituents easily volatilized. The lubricator recommended is a mixture of the less volatile portions of wax and vaseline. The phosphoric pentoxide should first be converted into solid metaphosphoric acid.

2. Many of the elements experimented upon could be sublimed, namely, selenium, tellurium, cadmium, zinc, magnesium, arsenic (metallic), and antimony, while those easily fusible, like bismuth, lead, and tin, are difficult to sublime; tin was non-volatile at a red heat.

3. Gas is evolved in the first distillation of most of the metals, but it is scarcely perceptible after repeated evaporations.

4. Sodium, selenium, tellurium, cadmium, zinc, arsenic, and antimony evaporate so easily in vacuo that this circum-

stance can well be utilized for preparing them in a pure state.

5. It is worthy of remark that most of the sublimable substances mentioned can apparently be melted and heated still farther in the same vacuum. It is probable that considerable differences in temperature effect but slight differences in pressure.

6. Many organic bodies that consist of easily decomposable mixtures, like tallow, wax, resin, etc., can be distilled in vacuo without decomposition, and thus be freed from impurities. This method may find many chemical uses.—*Wiedermann's Annalen.*

WATER-GAS.

MR. SUTHERLAND'S paper read last week before the Iron and Steel Institute serves to recall attention to a very old invention—an invention so full of promise that large sums have been spent on its development by sanguine capitalists, while it has served as a medium in the United States for more than one swindling transaction. It does not follow by any means that because an invention has been misused and misunderstood for a quarter of a century or more, it should be a completely worthless thing; and it may even be admitted that there is enough in the water-gas idea to entitle it to respectful consideration. Indeed, there is some reason to believe that, properly carried out, the process of making water-gas may be found useful if not profitable; and we propose to explain here what water-gas is, what are the uses to which it may be applied, and to indicate the position which the manufacture at present holds.

Water, as is well known, consists of hydrogen and oxygen combined, in the proportion of two of the former to one of the latter. The gases have a great affinity for each other, and readily combine if, when mixed in the proper proportions, a light is applied to them. If, however, the mixture be highly heated throughout, no combination will take place. The precise point at which this result takes place, known as the temperature of dissociation, has not been certainly determined. It is between 3,000 deg. and 4,000 deg. Fahr. There is reason to believe that the more highly the gases are heated, below this point, the less is the affinity which they have for each other. At temperatures of about 2,000 deg. the affinity of oxygen for carbon is much greater than its affinity for hydrogen. If, therefore, a current of steam is passed through a coke fire, the steam will be decomposed, the oxygen will fly to the coke, and hydrogen will be set free. Now, hydrogen is the most powerful heating agent we have. It is more than four times as effective as carbon, for while 1 lb. of the latter will evolve heat enough to convert 15 lb. of water from and at 212 deg. into steam, 1 lb. of hydrogen under the same conditions will evaporate 64·2 lb. of water. Nine pounds of steam contain 8 lb. of oxygen and 1 lb. of hydrogen; so that for each pound of steam decomposed we can obtain gas enough to evaporate $\frac{64{\cdot}2}{9} = 7{\cdot}13$ lb. of water. Bearing these facts in mind, we are in a position to arrive at the value of the process in a commercial sense. It must not be forgotten, however, that the hydrogen is useless as a lighting agent. Now, to make a pound of steam will require, with ordinary boilers working with cold feed water, say, one eighth of a pound of coal; but the hydrogen in each pound of steam would evaporate, as we have seen, 7·13 lb. of water. Consequently, a pound of coal will produce hydrogen—"water-gas"—enough to make $7{\cdot}13 \times 8 = 57{\cdot}04$ lb. of steam; and, so far, the economy of the process appears to be enormous. When, however, we examine what goes on in the generator, or disassociator, we find that the whole of the economy disappears. In a word, as much heat is expended in separating the two gases as they can subsequently give out again by recombining. The oxygen supplied by the steam is sufficient in amount to burn $\frac{8}{62{\cdot}6} = 8$ lb. of carbon to carbonic acid, with an evolution of as much heat as would evaporate 15 lb. of water, but as a matter of fact it is found to be in practice as in theory quite impossible to make the process continuous. The passage of the steam through the white hot coke cools this last down with great rapidity. In practice the cupola is urged by a fan for about 15 minutes; then the steam is turned on for 5 minutes, and so on. The production of hydrogen to be used as fuel in this way must be extremely expensive. The work done in disassociation cannot be performed without some loss of fuel beyond that theoretically necessary, and the hydrogen cannot be recombined—burned—so as to give out its full effect. Loss and waste of energy attend every step in the process, and hitherto for this reason all attempts to use water-gas alone as fuel have been failures.

In the Siemens gas furnace, air is admitted to coal or coke sufficient to produce an imperfect combustion. Each pound of coal is supplied with about 6 lb. of air, and the result is 2·33 lb. of carbonic oxide, CO, mixed with 4·7 lb. of nitrogen, which has no effect of any kind, save to act as a diluent, and reduce the heating power of a given volume of the mixture. The nitrogen, of course, finds its way in with the oxygen in the form of atmospheric air. If, however, we send in steam only, the oxygen of the steam will combine with the coke, and each pound of this will produce 2·33 lb. of CO; and we shall thus have a mixture of hydrogen and CO quite free, or nearly so, from nitrogen. The precise proportion of the two will vary in practice, as will readily be understood by those who have had much to do with furnaces. But the gaseous mixture thus produced is an admirable fuel for many purposes, and is, possibly, on the whole not much more expensive than the gas made in the Siemens producer—at least we are given to understand that it is not; and it certainly enables small coal, which would otherwise be totally useless, to be made available for producing an extremely clean and intense heat, as explained by Mr. Sutherland. In the United States a determined effort has recently been made by a Dr. Holland to utilize the system in propelling locomotives. The descriptions which have reached us of the Holland furnace are not so clear as we would wish, but it is easy to understand the general features of the arrangement as fitted to a shunting engine on the New York, Lake Erie, and Western Railroad. An iron retort is placed in the fire-box and kept at a very high temperature. Into this retort is poured heavy petroleum oil, drop by drop. The heat instantly converts this into gas, presumably a rather dense hydrocarbon. Steam is passed into the retort also. Its oxygen is seized by the carbon, and the result is a mixture of CO and H, which can afterward be burned in jets in the fire-box. It is claimed that no contraction of the blast pipe is necessary, and so no back pressure is set up; that no sparks are emitted, and that, so clear is the flame, a white handkerchief may be held over the chimney without being blackened—all which we can well believe. The heat can be regulated at will; the fire can be started in five minutes, and put out at once. The fire doors are never opened, and the evil of contraction, due to rushes of cold air, is quite avoided. We understand that the locomotive Dr. Holland, above referred to, has been used in working regular passenger trains as well as in shunting operations for more than twelve months with perfect success. It may at first sight seem that we have here our old friend, the petroleum furnace, in a new guise, but there are, we think, substantial differences between the two. It remains, of course, to be seen whether the Holland system will bear the test of constant hard work.

Our readers are now, we hope, in a position to form their own opinions concerning the value of water-gas as fuel. The essential feature in the whole process, the fact never to be lost sight of, is, that the value of the gas as a heating agent must be less than that of the fuel expended in producing it. Thus in Mr. Holland's engine, absolutely nothing is gained by sending steam into the retort save that the hydrocarbon gas is so much further enriched with hydrogen that it can readily be burned without the evolution of smoke or the deposit of soot, which would otherwise be an extremely difficult operation.—*The Engineer.*

SESQUICARBONATE OF POTASSIUM.

SESQUICARBONATES among the alkalies are not of equal frequency in their occurrence. Ammonia forms this particular carbonate in preference to the others, while the sesquicarbonate of sodium is quite rare, although it occurs as a natural product called Trona (Urao) in the salt lakes of North Africa and of South America. This was probably the *niter* mentioned in the Bible. While sodium and ammonium sesquicarbonates have been known for a long time, we know little about potassium sesquicarbonate.

Berthollet claims to have obtained it in 1809 by evaporating a solution of the bicarbonate over sulphuric acid in a vacuum, but he says that it got damp when exposed to the air. He does not seem to have made any analysis of it.

Berzelius stated that this salt could be obtained from solutions of the carbonate and bicarbonate, or of the bicarbonate alone, by boiling.

Mitscherlich doubted the existence of this salt.

In 1835 H. Rose examined the action of the bicarbonate solution more closely. When he followed Berthollet's directions, one-fourth of the carbonic acid escaped from the solution of the bicarbonate, but he thought this was mere accident, as the final result was a deliquescent mass containing single crystals of bicarbonate. When a solution of bicarbonate was kept over caustic potash and sulphuric acid for two weeks, nearly half the carbonic acid escaped, leaving a carbonate. A solution of the bicarbonate containing at first 44 per cent. of carbonic acid, contained 32 per cent. after half an hour's boiling, and after still longer boiling only 24½ per cent. remained, or ¾ and ½ respectively. Here too the final result was the carbonate, as only ¼ should have escaped to produce the sesquicarbonate.

Nevertheless, says Rammelsberg, in a paper read before the Berlin Chemical Society, Feb. 12, 1883, a sesquicarbonate does exist in a solid and crystalline form, although the conditions under which it is formed are not yet established.

According to a communication received from G. H. Bauer, at the Mineral Water Establishment of Drs. Struve & Soltmann, this salt was obtained by Lichtenstadt in the evaporation and crystallization of large quantities of bicarbonate solution.

The crystals neither effloresce nor deliquesce. They have the formula—

$$\left.\begin{matrix} 2K_2CO_3 \\ H_2CO_3 \end{matrix}\right\} + 3\,\text{Aq.}$$

Analysis A was made by Bauer, and B by Rammelsberg:

	A.	B.	Calculated.
Potassa	46·54	46·59	47·96
Carbonic acid	21·79	21·80	22·39
Carbonic acid	11·54	12·22	11·20
Water	..	..	18·45
			100·00

The crystals are monoclinic and the various angles and ratio of axes are given in the paper quoted.

Prof. Rammelsberg adds that he did not succeed in obtaining the salt from mixed solutions of the two carbonates. Bicarbonate separated in abundance, and the last crop from the mother-liquor was evidently a mixture of the mono and bi-carbonates.

THE CARBONIC ACID IN THE ATMOSPHERE.

AN important paper on this subject, written by E. H. Cook, has recently appeared in the *Philosophical Magazine*. Taking the polar diameter of the earth as 7,899 miles, the equatorial diameter as 7,925·5 miles, and the height of the homogeneous atmosphere at 26,214 ft.—nearly five miles—the cubical content of the homogeneous atmosphere is found to be 591,647,337 cubic miles, or in round numbers 592,000,000 cubic miles. If the average amount of carbonic acid in the atmosphere be taken as 4 vols. in 10,000, the total amount of carbonic acid is 236,800 cubic miles, and the total weight 4,287 billions of pounds, or 1,913,685,908,480,000 kilos. These numbers differ considerably from those given by Dumas and Boussingault, and from that given in Roscoe and Schorlemmer's "Chemistry." The first of these is nearly 40 per cent., and the second about 33 per cent. too high. Recent investigations, however, show that the proportion of carbonic acid in the atmosphere is not so high as 4 vols. in 10,000. Fittbogen and Hasselbarth found 3·4 vols. in 10,000, Farsky 3·4 vols., and Reiset 2·942 vols.; and if the mean of these be taken, the total weight of the carbonic acid in the atmosphere is nearly 1,545 billions of kilogrammes. The average amount of coal raised annually in the world during the last three years is about 280,000,000 tons. Assuming that this contains 75 per cent. of carbon, 10 per cent. of which is thrown away with the ash, 182,000,000 tons of carbon are annually converted into carbonic acid, which gives a daily production of 1,800,000 tons, or nearly 1,800,000,000 kilos. Assuming that one-third more is produced by the combustion of wood, peat, oil, etc., the total daily production by combustion is 2,400,000,000 kilos. The present population of the world is about 1,500,000,000, and each individual produces on an average a kilogramme of carbonic acid in twenty-four hours. Assuming that twice as much carbonic acid is produced by the respiration of the lower animals as by man, the total amount produced by respiration is 4,500,000,000 kilos. per day. The amount produced by the decay of animal and vegetable matter may be taken as equal to that produced by the respiration of man, and the amount sent into the air from subterranean sources may be fairly assumed to be five times as great as the total amount derived from all the other sources together. This gives about 40,000,000,000 kilos. per day. Adding all these quantities together it is found that the total amount of carbonic acid daily added to the atmosphere is at least 50,000,000,000 kilos., from which it follows that if no compensating influence were at work the proportion of carbonic acid would be doubled in about 100 years.

The causes which remove carbonic acid from the air are fixation of carbon by plants, removal of the acid by zoophytes, and absorption of the acid by inorganic chemical action. In the first case alone is oxygen returned to the atmosphere; in the other two cases the carbonic acid is absorbed as a whole. The total area of the land surface of the globe is, according to Saunders, 57,600,000 square miles. Of this 8,200,000 square miles are in Arctic and Antarctic regions, thus leaving 49,400,000 square miles on which vegetation might flourish. A considerable portion of this area is, however, occupied by barren mountains, cities, and rivers. Estimating the total area of leaf-surface at 50 per cent. of the area of plant-bearing land, it follows that 24,700,000 square miles, or 63,973,000,000,000 square meters of leaf-surface, are engaged in the work of removing carbonic acid. Since each square meter of leaf-surface decomposes about 1 liter of carbonic acid per hour, it follows that 63,973,000,000,000 liters of the gas are decomposed every hour. Taking into account the fact that sunlight, on the average, lasts only ten hours per day, and allowing 25 per cent. for diminution of the action during winter, the average amount of carbonic acid decomposed per day is 479,000,000,000 kiloliters, or more than 900,000,000,000 kilos. A considerable portion of the carbon thus removed is, however, returned to the air when the leaves decompose in the autumn; and allowance must also be made for the fact that some plants give off carbonic acid in the dark. On this point, however, there is no data on which to base any calculation, and the evolution of carbonic acid by the nocturnal respiration of plants may be much greater than is usually supposed. From the numbers given it would appear that the vegetable life of the globe is of itself sufficient to maintain the purity of the atmosphere. The removal of carbonic acid from sea water by low forms of animal life takes place on a gigantic scale, but the carbonic acid thus removed exists in the sea and not in the atmosphere, and a very large proportion of it must be derived from submarine volcanic eruptions. In all probability the influence of this action is felt only after many years, and so far as the atmosphere is concerned, it cannot be compared to plant life in point of activity. Large quantities of carbonic acid are removed by inorganic chemical changes, as, for example, in the conversion of orthoclase into kaolin—Sterry Hunt, *Amer. Jour. Sc.*, May, 1880—but any estimate of the rate of this action is impossible. These calculations seem to show that the causes which remove carbonic acid from air are more powerful than those which add the gas to the air. Its proportion must, therefore, be gradually decreasing, but there are no trustworthy data on which to base any calculations on this point. As to the source of the enormous quantities of carbonic acid already fixed in the form of limestone, we have no knowledge. Either at one time the atmosphere surrounding the earth must have been much richer in carbonic acid than it is at present, or, as Sterry Hunt supposes, there must be a universal atmosphere similar to our own, from which the carbonic acid now fixed in the earth's crust has been derived.

A WHITE PHOSPHORESCENT SULPHUR FLAME.

K. HEUMANN has found that this phosphorescence is particularly fine when sulphur is heated rapidly upon a plate in the interior of a metallic air bath to about 180° C (356° Fahr.). White flickering flames 10 to 20 cm. (4 to 8 inches) long fill the interior of the box. By regulating the gas flame it is easy to keep up this phosphorescent combustion for hours, without the ordinary blue flame making its appearance. There is nothing but sulphur dioxide produced by this burning.—*Berliner Berichte*, xvi., 139.

THE INSANE COLONY AT GHEEL.

A CORRESPONDENT of the *Boston Medical and Surgical Journal* (May 3, 1883) furnishes a very interesting account of a visit to the town of Gheel, which argues much for the advocacy of non-restraint in the treatment of the insane.

Gheel is within an hour's ride of Antwerp, and on one of the direct routes from Berlin.

At the time of his visit there were 1600 insane patients living around as inmates of the families of the colony, and in almost every case they were absolutely free from restraint.

One-half of the sane inhabitants of the town are employed in taking care of their insane fellow creatures, for which they receive pay from the government sending them or from friends of the patient himself, varying from $60 per year for paupers to $100 to $1200 for wealthier patients.

The colony is under the charge of a medical director and his assistants, who appoint the families to take care of the insane, this privilege being considered in the light of an honor for which all strive. The patients are separated according to the degree of their malady; the most quite and curable are located in the center of the village; those somewhat troublesome, but offering hope of recovery, are located not far from the center of the village, and to them is held out, as an inducement for good behavior, a prospective removal to the more desirable location.

The idiotic children are congregated in a hamlet where special educational advantages are furnished, although they associate freely with other children.

The town is divided into five sections, each of which is presided over by one of the assistant physicians, whose duty it is to make the round of his section once a month, while the director must visit the entire colony twice in the year. Each section is also under the charge of a non-medical "guard," an officer who has the general management, including the enforcement of sanitary regulations. A peculiarly quiet and orderly air pervades the town, which seems to result in part from the natural character of the inhabitants, and in part from a spirit of emulation among them, all wishing to be considered worthy of obtaining and keeping *pensionnaires*. The question naturally arising as to the effect on the normal mind of this constant and familiar association with the insane was answered by the statement that no more insanity exists among the permanent inhabitant of Gheel than among those of other places of its size, and that many families have handed down this occupation through generations without sign of nervous or mental affection appearing among their members.

While apparently doing as they please, the patients are carefully and intelligently watched.

The date at which Gheel began to be devoted to the care of the insane is hard to determine. It may with certainty be placed as early as the twelfth century, and legend carries it to a much earlier period.

[THE BUILDING NEWS.]

THE RATIONAL DRESS EXHIBITION.

THE Rational Dress Association have at last done something toward putting their ideas of dress reform into practical shape, and the exhibition now open to the public at Princes' Hall, Piccadilly, London, will be eagerly visited by all who desire to see what the reformers have to institute for women's attire as at present in fashion. It will be admitted, with some exceptions, that modern ladies' dress is a decidedly more artistic arrangement of drapery than that worn a few years ago. There is a closer study of the figure aimed at; the draperies hang with more grace, and are modeled with greater regard to the wearer's ease and movement. The Rational Dress Association appear to be rather divided in their views, and one of the chief differences between the would-be reformers is, to what extent the "divided skirt," as it is called, should be introduced into the new attire. The change, after all, amounts to the wearing

of trousers—more or less ample, and concealed by the skirt, which Mrs. King would have reduced to shorter and more convenient proportions—instead of petticoats as an undergarment. The advocates of reform are agreed upon one thing, namely, that there shall be no longer a wilderness of frill and insertion below a lady's skirts. On the score of economy alone, there might, perhaps, be an advantage in substituting materials for the undergarments which required fewer changes. The association have drawn up certain rules, and offered prizes. A prize of £50 is offered for a dress fulfilling the following requirements: That it should allow freedom of movement, an absence of pressure over any part of the body, that there must be no more weight than is necessary for warmth, and both weight and warmth must be evenly distributed; that beauty and grace are to be sought and combined with comfort and convenience; and that the new costumes must not depart too conspicuously from woman's ordinary dress. It will be admitted that these are rational conditions, and accord with medical opinions that have been constantly advanced.

blue material. The skirt is not too short, and the trousers of washing silk with a bottom pleating show below it. The latter garment is, in fact, the usual riding trousers worn by ladies. Another model shows a still more pleasing costume for a girl of 12 of a light figured material, and made on the same lines. The mantilla of silk exhibited by Madame Brownjohn is a decided improvement upon the usual constricted style of those garments. The arms, instead of being tied or held back, as is generally the case, are free of movement, and the effect is as graceful as the most approved form of mantilla now worn. We illustrate one or two of these costumes. Confining our attention to dresses suitable for exercise, we find, with few exceptions, they are made up of dark gray or warm-colored merinos and serges, with divided undergarments. A cricketing costume, with a short, loose tunic and trousers, is a highly rational dress for such a pastime. In another case we see a walking dress, consisting of a divided skirt and polonaise, with flannel combination garments underneath of silk, sent by a Manchester modiste. A calisthenic dress, by Miss Fowler, exhibits a tunic and short skirt tied in at the waist with short gathered knickerbockers, which do not conceal the lower part of the legs, very well adapted for active exercise. A dress for tricycle riding, by Mrs. King, is a combination garment of the ordinary riding trousers and knickerbockers, and answers very well for the free movement of the legs. Lawn tennis, as a fashionable ladies' game, has not been forgotten by the new costumers of rational garments. It is a divided skirt and body of woolen or serge material, with smocked sleeves giving free movement of the arms and waist. The color is a bluish green. The dual divided skirt and tunic by Mrs. Beck, of Hyde Park Square, is also noticeable. While some of these possess all the requisites required by the committee, and avoid constraint of the body, we cannot altogether lose sight of the fact that there is a bagginess and fullness in them which are not very attractive to the admirers of the feminine figure, especially the bust. Nearly all of them have adopted the loose-fitting jacket body or tunic, and double continuations or trousers, generally kilted or gathered. In a few the trouser legs are baggy, and so large as to give rise to the objection that the substitution of them for the ordinary undergarments would not add to the comfort of the wearer. The general principle of suspending the dress appears to be to distribute the weight upon the shoulders, and not to let it rest on the hips. A working woman's costume of gray linsey, a combination vest and trousers with a loose tunic over, seems well suited for women engaged in factory work. One of these costumes is described as consisting of a stocking suspender, a combined suit of thin flannel, worn next the skin, with, for winter wear, a high-necked sleeved suit of thick flannel, and for summer a low-necked, short-sleeved suit of calico; a skirt, with shaped band, buttoned on the outer combined suit, of bats' wings, felt, or alpaca, and relieved by long kilts at the bottom. The figure is well sustained by a sort of crinolette. There are other models: one with a loose serge jacket, vest, and pegtop trousers and cloth gaiters; and another, exhibited by Mrs. Boecklin, of the United States, a kind of short paletot, with long vest and pegtop trousers. Both these are without skirts, and have been adopted by ladies in the United States for some time. A light serge boating dress, with long continuations, is a sensible costume for ladies who are fond of rowing. Our notice of the exhibition would be incomplete were we to omit to mention one or two very attractive evening costumes, one of which we illustrate (Fig. 8). It is exhibited by Madame Worth & Co., Parisian modistes, and shows a figure of a lady in a light dress of blue surat, large, loose, Albanian sleeves, freely suspended from the shoulders. The skirt is short, and with the trousers is hung from the waist. There is an elegance in the lines of draperies, which, however, may be deemed rather full, and the long, flowing character of the bodice is quite out of scale with the short frilled skirts. A dancing costume of blue satin and silk, trimmed with lace, waistcoat and jacket-body, is certainly an improvement on the dresses often worn at balls; and so is Madame Grace & Co.'s trouserless costume, though it departs little from the modern style.

It is rather too soon to offer any very decided opinions upon the merits of the new dress. Public taste and criticism are invited by Mrs. King and her colleagues; but we think there can be but one general opinion that the "divided skirt" or trouser costume as we are here confronted

Looking at some of the costumes in the exhibition, some of which we have sketched herewith, it will be easy to find fault with details which a little more careful study of the figure would have avoided. The chief of these are the rather ill-modeled "dummies" on which the garments are shown. Mrs. King's red and black trousered suit (Fig. 4) is upon one of these frames, which certainly does not recommend the costume. Madame Brownjohn exhibits a very useful traveling dress, which can be easily converted into a dinner dress in five minutes without assistance. The style of the costume need not offend the most conventional taste. It consists of a rich plum-colored merino with the addition of a figured satin skirt, which the wearer can assume for evening attire at a moment's notice. Lace trimmings can be buttoned on the upper garments, and a handsome dress is at once produced. A robe with divided skirts giving full freedom of movement, and weighing only 1 lb. 10 oz., is made all in one. There is a sort of open jacket body and vest buttoned up with pearl buttons in front with elastic waist made of washing silk (a small blue check), a skirt of the same material. The vest trimmings are of a dark navy

with is not that best fitted for the female form. Even Mrs. King herself, in her lecture on "Dress," which we reported, has doubts in her own mind as to the propriety of the trouser as a proper covering, for she is willing to allow that it is not a very beautiful garment. To our mind it is far less graceful than the knickerbocker. To see two frilled trouser legs appearing just above the boot, and a few inches below the skirt, as in one Manchester model, might suggest a man in a woman's skirt; but nothing can be uglier. The Bloomer costume, and many of the peasant costumes worn on the stage, would be far more artistic as models. Every one will readily admit a shorter skirt than that usually worn is desirable and proper for ladies' walking dresses, and for working and factory women and girls it is absolutely necessary. The hanging of graceful drapery about the waist without restraining or fatiguing the body is almost essential to a perfect costume for women. Few of the reformers have been very happy in their ideas. One of the most successful attempts by Messrs. Debenham & Freebody we have illustrated (Fig. 3). Here the navy blue close fitting jersey conforms to without restricting the figure, and the skirt hangs in graceful folds. The same firm sends other pleasingly draped figures. Mrs. Nettleship has also shown some good taste in her girl's dress, and for young girls the short skirt and simple gathered waist, with kilted terminations, are very becoming and exceedingly pleasing (Fig. 2). The smock-frock like gatherings to the wrists and neck are very suitable, and give an elegance and finish. A portion of this work is drawn in detail.

The exhibition must, of course, be viewed as a transitory stage of the dress reform movement. Invitations are offered for designs for the dress of the future for both gentlemen and ladies, upon the conditions laid down; though, as regards the last one, a greater departure from ordinary dress is permitted. It is remarkable so few have attempted anything in the reform of gentlemen's dress, and, to our thinking, it was chiefly in the dress of the male portion of society that an artistic reform was needed.

The following reference notes are descriptive of the specimens sketched as representative of the "Rational" dresses exhibited:

Fig. 1.—An admirable dress for a young girl, made in light figured stuff, suitable for summer wear. A long, flowing line is obtained by a fall from the neck behind and in front a wide pleat carries out the same idea. The drawers are of the same material as the rest of the dress, and lace frills form a finish for the neck and wrists. Madame Brownjohn is the designer.

Fig. 2.—Mrs. John T. Nettleship's gray green stuff dress, with buff trimmings and smock-frock like gathered wrists, and collar necking to the upper part, is a most successful dress, set off with a wide blue silk sash, and hanging pocket suspended from the high waist.

Fig. 3.—A navy blue jersey jacket and kilting to be worn over a skirt. The collar is an elegant feature and forms a sort of breastcoat fly in front; behind, it extends across the back from the armpits. Messrs. Debenham & Freebody are the makers.

Fig. 4.—This is Mrs King's "Dress of the Future." The sparrowtail jacket is in figured velvet, trimmed with beadings at the edge to the sleeve openings and hips. A heavy sash is brought round under the jacket in wide folds, and is tied in a large loop knot with a red silk pocket handkerchief tucked in to give a touch of color. The sleeves are in black satin, trimmed with a band of red satin at the wrists, and the trousers are in the same material, with red satin slashings. The several extremities are finished with lace.

Fig. 5.—A check blue jacket and navy blue dress, having a divided skirt in front and back halves, and below complete trousers. It weighs only 1 lb. 10 oz., and hangs entirely from the shoulders, being made in one piece. It is one of the most sensible dresses in the exhibition, and Mrs. Brownjohn is its author.

Fig. 6 has a port wine silk collar, trimmed with white lace, and the dress is made of figured white silk, enriched by old fashioned flowers in bright colors. The kilted petticoat is in white, with lace edging, making as a whole a very rich costume.

Fig. 7, by the same makers, Messrs. Debenham & Freebody, is a plain white serge jersey and skirt relieved by a port wine colored silk sash or girdle. The close fitting character of the bodice, with the high neck and the wide graceful folds or pleats of the skirt, make the dress an admirable one

Fig. 8.—Madame Worth & Sons' ball dress in blue silk, trimmed with pearls. The arms are slashed with pink, and wide lace frills trim the sleeves and drawers and skirt flounces.

Fig. 9.—This is Mrs. Blair's, of Manchester, own dress. It is made in cinnamon colored diagonal serge cloth, and has trousers and belt to match. It is the climax of the Exhibition.

"PEAR GRIT" AS A CAUSE OF ANAL IRRITATION.

By DR. J. T. ROTHROCK, of Philadelphia.

FOR three successive summers my attention has been called to a case for which I can find no exact parallel in our

"Pear Grits" *i. e.* Stone or Sclerenchyma Cells from the Pear. Clusters magnified about 200 diameters.

medical literature, and as it presents some marked features, is, perhaps, worthy to place before the medical public; especially as the diagnosis is easy, the treatment merely abstinence from the offending cause, and because, further, it may give a clew to many other cases with like symptoms.

The patient, a middle-aged strong, active man, very fond of fruit, each summer was taken with what he first supposed a "fit of piles." There was excessive pain on defecation, tenesmus, flattened feces, and a more or less copious discharge of blood. At one time the pain was so severe and so distinctly localized as to lead to the suspicion of fissure or ulcer of the anus.

The periodical return of these attacks was suggestive, and induced an examination for cause.

Among the fruits quite too freely indulged in by the sufferer were pears. This at once suggested the inquiry as to whether the "grit" that all, even the best pears, contained might not have to do with the trouble. On mention being made, it at once brought to mind the fact that on the paper used in the closet there were small white hard bodies, never larger than the head of a pin.

Examination by the microscope revealed the fact that in the feces there were quantities of bodies like those shown in the figure—clearly the so-called sclerenchyma, or stone cells, of vegetable histologists. This furnished the clew to the treatment, which was simply to abstain from the pears, a cure always following.

An idea of the hardness of these cells may be gained from the statement that they are of exactly the same material and hardness as the shell of the hickory nut.

One may readily understand from this, and from the numerous sharp angles a cluster of these cells show, that lodged in the folds of the mucous membrane at the verge of the anus, even if it were not in an inflamed condition, it would speedily become so, and that to an inflamed or ulcerated membrane it would soon prove an intolerable source of distress.—*Med. and Surg. Reporter.*

DEFORMITIES AND HERMAPHRODITISM IN CRUSTACEANS.

Compiled by C. F. GISSLER.

DR. WALTER FAXON recently* described and figured a large number of crustacean deformities and divided them into five categories, viz.:

Deformities: 1, of deficiency; 2, of excess; 3, of transformation; 4, of arrested development; and 5, of hermaphroditism.

1. In individuals of this class, certain parts normally present are wanting. They are never congenital among crustaceans, but result from accidental amputation of parts commonly restored by growth.

2. Under this head fall the majority of the monstrosities that have been described among arthropods. Professor Jayne lately described and figured such cases three years ago in the "Transactions of the Amer. Ent. Society," vol. viii. In these cases it is commonly the antennæ and legs which are the seat of the monstrous development, which usually take the form of a duplication or even triplication of the appendage. Among crustaceans these examples are very rare. In this category are included specimens of female craw-fish (fresh water lobsters) noticed by E. Rousseau with an extra pair of vulvæ on the basal segment of the fourth pair of legs, the oviduct of each side dividing into two branches after leaving the ovary.

3. Monstrosities of this class result from an organ being replaced wholly or in part by another organ. They are common in plants, but exceedingly rare in animals. They were noticed in *Prionus coriarius*, a European longicorn beetle, with two perfect legs in place of the wing-covers or elytra; in *Cimbex axillaris*, a stinging bee, with a claw like those of the tarsi (toes) on the end of the left antenna; in *Zygæna filipendulæ* (a butterfly), with one of the hind legs replaced by a wing. Among crustaceans the only example of this kind of monstrosity is the *Palinurus penicillatus*, in which a flagellum like one of those of the antennules is developed from the center of a rudimentary cornea on the end of the eye-stalk. Monstrosities of this class are especially interesting on account of their bearing on the morphology of organs.

4. In *Lupa* and some other genera of crabs dimorphism occurs in the females, many full grown specimens having a narrow and acute abdomen, instead of a broad, roundish abdomen of the normal individuals. These females, upon examination, proved to be sterile, and may be properly classed among abnormal variations caused by arrest of development.

5. *Hermaphroditism.*—While numerous cases of hermaphroditic insects have been put on record by entomologists, but a few undoubted cases are known among crustaceans outside of those groups in which it is the normal condition, viz., the barnacles and certain isopods. One case is that of a lobster. In this specimen the right half of the body was female, the left half male, as regards both internal and external organs.

Another similar case has been recorded in a specimen of a fresh water shrimp (*Eubranchipus*). An account has been given of three specimens of *Cheraps* with openings in the first segment of the third pair of legs answering to the sexual apertures of the normal female, coexisting with the normal male sexual orifices in the first segment of the fifth pair of legs. An examination of the internal parts showed the coiled "vasa deferentia" of the normal male opening out through the apertures in the fifth pair of legs. No ovary or duct leading to the openings in the third pair of legs was detected.

I now give an account of an interesting paper which at the time was unknown to Dr. W. Faxon. It appeared in the forty-ninth volume of the *Sitzungsberichte d. K. Acad. d. Wiss.* I. Abtheilung, Feb., 1874, by Wm. Kurz: 'On Androgynous Malformation in Cladocera."

The entire literature of the Cladocera (crustaceans) does not know of a single case of hermaphroditic malformation. I recognized several specimens exhibiting both external and internal hermaphroditism. In October, 1873, at the time when the males began to become more frequent, I found among numerous male and female individuals of *Daphnia pulex* (water flea) a hermaphrodite, which first struck me by its peculiar formation of the antennæ (Fig. 1). The right antenna of the first pair was short, as in the female, and situated under the apex of the rudimentary rostrum; on the other hand, the left was formed after the type of the male antenna, without, however, having its usual size.†

It projected largely from beneath the short rostrum, bore on its tapering end the flagellum with a strongly outlined base and below the fascicle of short, cylindrical olfactory setæ, while on the anterior antennal margin, in addition, the small sensory bristle of the male antenna was inserted. Abstractedly from the difference of the two sensory antennæ, the entire habitus of the animal yielded already a sufficient number of differences in comparison with the adult female as well as also with the adult male. The side view of the body approached more the female structure, the dorsum was curved, the head was much less bent downward than in the male; yet the rostrum was reduced, holding about the middle between the male and female rostrum.

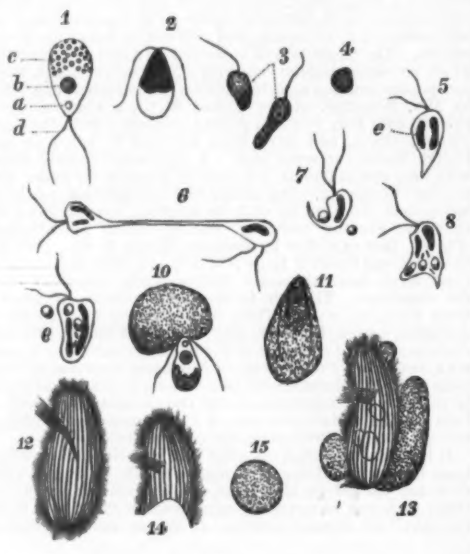
The spine was likewise much shorter than in the female, but its position and direction were decidedly female. Still more, the anterior angle of the shell recalled the male character, which however did not so widely project as in the male, but nevertheless caused a gibbous interruption at the continuous rounding of this place in the female, and was on both sides densely beset with long bristles. The first pair of legs, like the antennæ, showed an unequal formation; the right leg was female, the left decidedly male, provided with a claw and flagellum.

In look the post-abdomen was female, but the genital organs were peculiarly malformed. On the right side the genital gland was represented by an ovary, plainly exhibiting germ-vesicles and fat globules of the yelk; the effering duct, however, did not, as in the females the ovaries do, *i. e.*, discharge dorsally near the abdominal appendages, but the duct bent, parallel with the intestine, into the post-abdomen, where it could be followed by some distance, however leaving me the genital porus in the dark. The testicle was normally developed on the right side, and filled with zoosperms, the *vas deferens* also had its normal course. The incubatory pouch was undeveloped, and the three dorsal appendages, especially the uppermost, were also rudimentary only.

The size of the animal kept the middle between the size of the male and female, since, while the former measures 1 to 1·1 mm., and the latter always over 1·5 mm., the hermaphroditic specimen measured from the front to the base of the shell spine 1·34 mm.

Consequently, this individual, as a whole, was a laterally (though incomplete) separated hermaphrodite with the male sex predominating, which latter was especially expressed in the efferent ducts of the genital glands. Previously, already, on August 4, 1873, I had come across a hermaphrodite of *Daphnia schæfferi*, but could not study it up then on account of lack of time and on account of its lesser transparency. Nevertheless, I take its hermaphroditism as sufficiently proved already from its external characters (Fig. 2).

The dorsum was entirely straight and horizontal, as in the male; the *fornices* (arches) ran out exteriorly and posteriorly in unusually acute angles, and continued in a widely projecting and dentate bead, which ran parallel with the dorsal ridge, horizontally along the shell valves, and became gradually lower toward the posterior shell margin. The shell sculpture was normal, as met with in males and adult females; the meshes below the ridge were triple contoured, but single above it.



All other characters recall more the structure of the parts in females. The anterior angle of the shell, for instance, was evenly rounded, without gibbosities, lacking also the striking pilosity* of the males. The legs and the post-abdomen decidedly exhibited a female character; the uppermost of the four dorsal appendages was a little less than half as long as in adult females. The incubatory space remained undeveloped. The sensory antennæ only were of a pronounced hermaphroditic character; the right was female, but the left remained incompletely male, since it remained far behind the usual size, lacked the sensory bristle and the pennate bordure of the flagellum. This hermaphrodite, therefore, comes in the category of "mixed" hermaphrodites.

Finally, on November 1st of the same year I met with a hermaphrodite of *Alona quadrangularis* (Fig. 3). Its habitus was perfectly male: dorsum horizontal, rounded at the posterior angle. The posterior margin of the shell-valves passed with a gradual curvature over into the lower margin, which ascended obliquely before the middle, and in the short anterior margin passed over in a projecting but dull angle. The entire lower margin was pilous; the angle especially was more densely beset with longer hairs. The greatest height was not, as in the female, posteriorly, but a little before the middle of the shell-length. The sensory antennæ were of the length of the rostrum, both equally long; terminally they bore the fascicle of the unusually long olfactory setæ; very close and above it was the normal sensory seta, but in addition to which, on the left antenna above the seta and a little exteriorly, was the flagellum, which is characteristic for the male sex; its length was inconsiderable. The legs of the first pair were different; on the right was a female leg; the left had a rudimentary hook, which was a good deal smaller and shorter than in the adult male. The post-abdomen presented the greatest irregularities. It was club-shaped, strongly broadened toward the apex, and provided with the aculeate armature of the female.† But the upper margin‡ was totally anomalous, from the female as well as from the male structure, being gibbous and bulging;* the exit of the common *vas deferens* of the bilateral sexual glands occurred before the highest elation. The relation of the latter was the same as in the above-mentioned hermaphrodite of *Daphnia pulex*. That is to say, on the left the male apparatus is fully developed, the testicle full of sperm, on the right neither sperm nor germ-vesicles could be found, but a yelk mass of smaller granules and large round fat globules. Consequently this was an ovary with nearly mature eggs. Again, the efferent duct was curved downward in the manner of the *vas deferens*. What particularly struck me was the unsymmetrical distribution of the fat in the body, since, while the left (male) side was almost without fat, the right side showed numerous orange-colored fat-globules embedded in the connective tissue. This hermaphrodite likewise held in size the middle between male and female. Some measurements show best the similarities and differences.

	Female.	Male.	Hermaph. I.	Hermaph. II.
Length from rostrum to posterior margin of shell ...	mm. 0·84	mm. 0·72	mm. 0·8	mm. 0·74
Greatest height of shell valves....	0·46	0·35	0·42	0·4
Length of post-abdomen inclusive claw..........	0·4	0·32	0·33	—
Greatest width of same....	0·1	0·094	0·11	—

The as Hermaphr. II. mentioned hermaphrodite was observed and figured in May, 1873. At that time I was not yet acquainted with the male of *Alona quadrangularis*, and took this hermaphrodite for a time for the male. Later on numerous specimens of males were at my disposal, when I succeeded artificially to domesticate them.† I then, of course easily found the numerous abnormalities of this specimen, but not till I found the above-mentioned hermaphrodite an understanding was obtained in the organization of the hitherto puzzling individual. The drawing represents the right side of the animal. The outline is male, both sensory antennæ are female, the right anterior leg is male; the post-abdomen shows the female aculeate armature; has the upper margin wrinkled, plicate-like; the *vas deferens* was plainly visible, but it discharged earlier than is the case in adult males. To my regret I did not examine the left side; the genital gland of the right side also escaped my attention.

These four described hermaphrodites I found within a short space of time and without having purposely looked for them; from this may be inferred that androgynous malformations among Cladocera are perhaps of more frequent occurrence. All circumstances point to this. The female which produces during its whole life again only females, shall suddenly, without an exterior motive, without preceding fertilization, commence to produce males. In such a male egg-germ a relapse into the female formation is presupposed. The facts also speak for this assumption, as all hermaphrodites were found at a time when the males just began to appear, and were still very rare; in this manner the transition from the exclusive generation of females to that of males would be brought about by hermaphroditic malformations.

CHILDREN SHOULD STUDY NATURAL HISTORY.

THE fear of inoffensive animals seems to be as truly a source of danger as ignorance of the harmful and venomous. Within a few days the children in a school in this city were panic-stricken by the entrance into the school room of one of the harmless insects known as the devil's darning needle. While no evil followed, the possible results of a panic are only too well known.

The occurrence, says the *Sun*, emphasizes the importance of general and thorough instruction for children in elementary natural history.

At the public schools, both in the city and in the country, the pupils should be taught something about the common animals, birds, insects, and plants of the region in which they live. They will thus learn to distinguish between that which is harmless and that which is harmful in animal and vegetable life, and their knowledge in this field will possess a practical value which does not belong to every branch of study, even in our public schools.

* Bulletin of the Museum of Comparative Zoology at Harvard College, vol. viii., No. 13. "On some Crustacean Deformities." Cambridge, Mass., March, 1881.

† Compare F. Leydig's illustrations of the male and female of *Daphnia pulex*, in his "Naturgeschichte der Daphniden," 1860, Tab. I., Figs. 1 to 5.

* Leydig, *loc. citat.*, Tab. III., Fig 23, and Tab. II., Fig. 21.

† P. E. Müller, "Danmarks Cladocera." in "Naturhistorik Tidsskrift," III. Række, 1868. Tab III., Figs. 20 and 21.

‡ I mean that margin which the animal in repose bears curved upward toward the venter; with stretched out tail it becomes the lower margin, and as such it must morphologically be interpreted.

* Among the males of *Lynceidæ* this is not so rarely occurring; it even seems to be the rule with some species, that this margin has gibbosities. P. E. Müller found the male of *Pleuroxus personatus* (*Rhypophilus glaber*, Schoedler) provided with such a tail (*loc. cit.*, Tab. IV., Fig. 22), and I can not only verify this statement, but add yet, that also the male of *Pleuroxus trigonellus*, O. F. Müller, possesses a similar post-abdomen, whereby a new proof is rendered to a contraction of the genera *Pleuroxus* and *Rhypophilus*.

† It is usually stated that the males of *Cladocera* appear in fall. But I had repeatedly occasion to make interesting observations on these relations. On April 7, last year, I found females with ephippia and males of *Daphnia galeata*, Sars, in a cistern in such a number as to render the water unfit for drinking. The day following I met with a new undescribed species of *Daphnia*, both males and females, in a small ditch, just about drying up. During the summer I visited several times this locality, near the town of Deutschbrod, and found after nearly every good rain the ditch filled with water and populated by the same *daphnia*; but as soon as the water began to evaporate, the males reappeared. The thought struck me to artificially imitate the process of drying up. Into a richly populated aquarium I placed a few cotton threads in such a manner over the edge of the glass that they with one end dipped deeply into the water, but that they with the other end reached into another, empty glass jar. Through the effect of capillarity the water very slowly began to trickle over, so that the water in the aquarium after two weeks was reduced to its sixth or eighth part. At this time the remaining water contained numerous individuals of both sexes of *Simnocephalus vetulus*, *Eurycercus lamellatus*, *Alona quadrangularis* and *A. leydigii*, Schoedler, although it was but middle of May. But other similar experiments with *Macrothrix* and *Ilyocryptus* did not come to the point. On the other hand, however, the males of *Eurycercus* and *Simnocephalus* developed from themselves and without my meddling with them, in putrefying water; the females probably notice in the putrescence of the water a danger for their existence. From these observations I inferred that the males of *Cladocera* are not produced until that time, when the females begin to regard the waters of their habitation quantitatively and qualitatively as insufficient for the sustenance of their life. This makes its appearance, first, when the water evaporates; secondly, when it chemically changes; or thirdly, when it reaches an unbearable degree of temperature. These events must, moreover, go on sufficiently slow, to give the females time for the development of the male embryos. But the same degree of water putrescence does not hold good for all genera and species; some are very sensitive toward the least change of their vital relations, as, for instance, *Leptodora*, *Polyphemus*, the *Sididæ* and most *Daphnidæ*; the majority of the *Lynceidæ* appears to be less sensitive, among which again the genus *Pleuroxus* is marked for its endurance; but the highest degree of indolence possesses the *Bosminidæ* and *Lyncodaphnidæ*, of which hitherto the fewest males are known. There are perhaps species which, through the climatical influences of our districts, are not at all compelled to a production of males.

Every summer we read of children killed by mistaking some poisonous plant for another plant which is good to eat. Toadstools are taken for mushrooms, and people heedlessly stroll into masses of poison ivy without any idea of the danger. Hundreds of innocent insects are looked upon as venomous, simply because nothing is known about them, and, on the other hand, an unsophisticated youth from town occasionally picks up a real old yellow-jacketed wasp, under the impression that it is only a yellow fly.

Illustrations could readily be multiplied to show how little people know about what we may call the natural history of common life. No study is more attractive, and none more suitable for our public schools, after reading, writing, and arithmetic. We are inclined to rank it in importance even above geography.

SUN-FISH SHOOTING, COAST OF IRELAND.

THE sun-fish is, as regards its general appearance, truly a "caution" to the fish tribe. One of its most frequent haunts is off the wild and rocky coasts of the west of Ireland. Its length varies from five to nearly seven feet from the nose to the tail, if indeed such an apology for a caudal appendage may be called a tail. It is from three to four and a half feet in depth; from seven to nine feet in girth; and its extreme thickness varies from one and a half to two feet. When full-grown, these fish attain to an enormous weight, specimens having been killed which were estimated to weigh over a ton.

The sun-fish make their appearance on the west coast of Ireland as soon as the warm weather begins. They are gregarious for the greater part of the season, moving about in "schools" in numbers varying from five to ten; but as the autumn draws on they are more frequently to be met with singly.

On a warm day, when the sea is calm, these fish may be observed lazily gliding through the water, with their great dorsal-fins projecting from the surface. Or they may as frequently be seen basking on the surface with sea-gulls perching on their backs, and pecking at the parasites which they find upon the huge monsters.

When struck with a bullet just at the butt of the dorsal-fin, the movements of this great fish are truly wonderful. At one moment he will turn round and round, churning the water into masses of foam. Bullet after bullet is then fired into the fish; the shots being easily obtained, since the fish usually remains at the surface, if the first shot between the fin and back-bone has been successful.

In the case before us, the fish, after receiving five shots (fired, by the way, from a double-express rifle), disappeared bodily, leaving a large part of the sea white with foam and flecked with blood. Yet only for a minute. Not many yards in front of the boat, our piscine friend, *O mirabile visu!* suddenly burst up from the water and rose four or five feet into the air, and then striking the water with its expansive side, caused a tremendous report.

After receiving eight shots, the fish finally succumbed, and while one of the boat's crew held up the defunct brute with a gaff, another fastened a rope to one of its fins, and then the prize was towed to shore. Yet the fish is comparatively valueless; for, notwithstanding its great size, very little oil is obtained from its liver, the average quantity being about four gallons.

As a sport sun-fish shooting takes a prominent place among its votaries, and, moreover, little skill is required, for if one can affirm his ability to hit a fair-sized haycock at the distance of ten yards, he may make pretty certain of hitting the ugly sun-fish, if he be not overcome by excitement.—*The Graphic.*

THE FISHERIES EXHIBITION, LONDON.

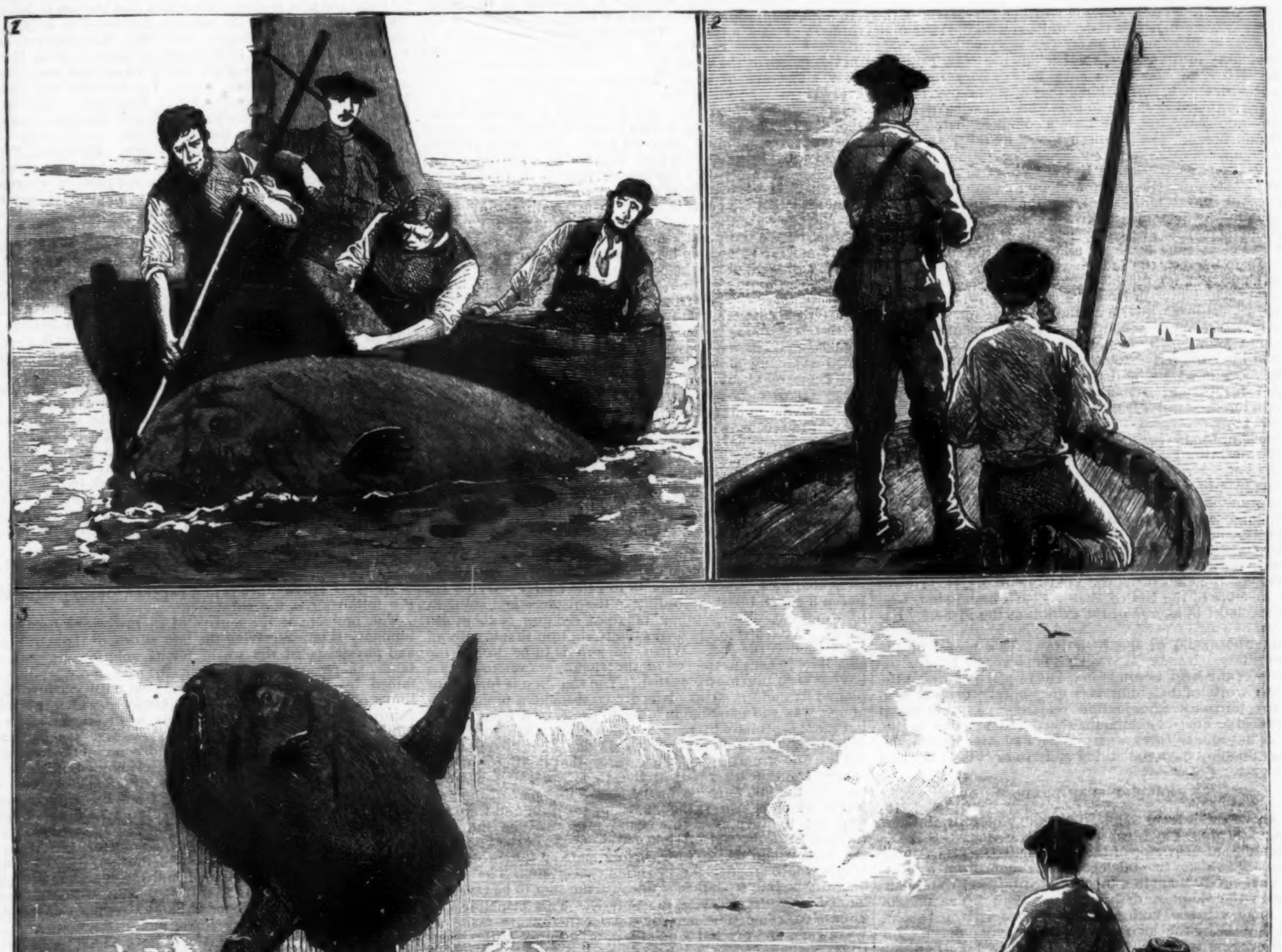
THE AMERICAN FISH-HATCHING STEAMER FISH HAWK.

ONE of the most important series of models in the Exhibition, says *Engineering*, is that which illustrates the United States steamer Fish Hawk, and the work she is engaged in. There is a scale model of the vessel herself, from which we have taken approximately the following dimensions: Length over all, 160 ft.; breadth, 27 ft., depth of main hold, 12 ft.; depth from main deck beams to upper deck, 7 ft. 6 in. She is built of iron and propelled by twin screws, being very light in draught.

The Fish Hawk has been constructed expressly for the purpose of propagating the marine and anadromous fish of the American seaboard, and has a complete set of hatching apparatus on board. The shad is the principal fish operated upon, but cod, alewife, and Spanish mackerel occupy a considerable portion of the attention of the scientific staff attached to the vessel. The advantages of a moving over a stationary fish-rearing establishment are very marked, and the United States Fish Commissioners have displayed a readiness of application of means to an end characteristic of their country in adapting the Fish Hawk to her special vocation.

On the main deck are eighty-four sets of Bell and Mather hatching apparatus, each one consisting of an inverted cone made of copper and nickel plated inside, and of a capacity of about 8 to 10 gallons. They are hung in gimbals, so that the motion of the ship will not affect them and cause the water to spill. The apex of each of these cones is connected to a small pipe, which in turn is in communication with a main filled with water kept under pressure by means of a small pumping engine. Near the top of each cone is an overflow pipe. The fertilized eggs of the fish are placed in the interior of the cone, and when the water is put into circulation they will be kept constantly and gently moving by the action of the flow. Each cone contains 60,000 to 75,000 eggs, the majority of which are duly hatched and turned overboard at proper times. This apparatus is all contained inboard, and is used in bad weather, or when the vessel is under way. When the ship is stopping for any length of time in a snug anchorage an outside hatching apparatus is brought into play. This consists of a long spar or boom rigged parallel to the ship's side, from which it is held a distance of about 3 ft. by means of iron outriggers, the latter being hinged at each end, so that the boom can be raised or lowered at will. Pendent from the spar and immersed about 18 in. in the sea, are a number of "Ferguson's plunging buckets," which are simply cylindrical copper buckets of 18 in. diameter, and 24 in. high, fitted with wire gauze bottoms. By means of a small steam engine and an arrangement of eccentric gear, the spar with the buckets attached is made to fall quickly and rise again slowly through a space of about 4 in., by which means the water is kept constantly circulating, but at the same time the eggs are not unduly pressed against the wire gauze bottom of the bucket. One of these buckets will contain about 200,000 shad eggs, and there are frequently 40 to 60 buckets outboard at one time.

The Fish Hawk, with all the necessary apparatus of a piscicultural establishment on board, commences operations at the extreme south of the United States Atlantic seaboard, off the coast of Florida, in January or February, at which time the shad will be spawning in that part. The vessel will take up her station as near as practicable to the fishing fleet, and will then send out her boats containing the spawn takers, who go alongside the fishing boats, and when a ripe fish is brought up by the fisherman, they will "strip her," that is, squeeze out the eggs into a pan provided for the purpose. The fish is then put in with the rest of the catch, and duly sent to market. When a ripe male fish is taken the melt will be squeezed over the eggs, which will thus become fertilized. A sufficient quantity having been thus obtained, the collector will return to the vessel, and the eggs will be placed either in the inboard or outboard hatching apparatus, as circumstances may demand. The time occupied in hatching the eggs of the shad varies with the temperature, and may be as little as three days in warm weather, or as much as eleven days if the water should be exceptionally cold. The young shad live on minute crustacea, but it is no part of the programme of the Fish Hawk to feed the fry she helps to bring into existence, and they are accordingly turned overboard three or four days after having been hatched, before the food sac which is attached to them when they emerge from the egg has become quite absorbed.



SUN-FISH SHOOTING, COAST OF IRELAND.

It would be difficult to estimate the enormous advantage that such a system as that pursued by the Fish Hawk would have on a fish supply failing from being overworked. At one station alone, and within the space of two months, the Fish Hawk has brought into the world fifty million young shad, and although many of the eggs so hatched would in the course of nature have become fry, yet it could have been comparatively but a small part. A vast proportion of the eggs deposited by the female fish remain barren and perish through not coming in contact with the fertilizing melt, but the spawn collector takes care that there shall be no miscarriage in this respect. Another great use of the Fish Hawk is in extending the geographical range of any comparatively localized species of fish. For instance, Professor Baird, who is the head of the Fish Commission, hopes to bring the cod down as far south as the Virginia coast, while at present its southern limit is the New Jersey seaboard. Sometimes the Fish Hawk will take into her hatching apparatus a stock of eggs of any particular description of fish, with which she will sail to a river or estuary where such kind may have been before unknown. The young fry will then be turned out, and if circumstances are favorable the waters will thereafter become productive of the fish in question. The wholesale manner in which the Fish Hawk can alter the geographical range of a whole species of fish, as it were, at one blow, quite satisfies the conventional English idea of the bigness of American undertakings.

As the year progresses and the weather gets warmer, the Fish Hawk steams north in order to keep with the spawning fish, so that in May she will be off the Maryland coast and by about July in the extreme north off the New England States. There are also three large flats or barges working with the Fish Hawk, and forming part of the system. These flats work principally in the sounds and estuaries of North Carolina and Maryland, and have a complete hatching apparatus on board. Having been towed by the Fish Hawk into a suitable position, they commence operations by sending out the spawn-collecting boats. These, to the number of five or six, are generally towed by a steam launch, detailed by the naval authorities for the purpose, on to the fishing ground where the fishermen's boats are at work, or where the seine nets are being hauled, as the case may be After sufficient time has been allowed for the collectors to gather their harvest, the launch returns to the floating station or barge, picking up the collecting boats *en route*. The eggs are packed in "McDonald's shipping crates," which consist of shallow wire trays, the bottoms of which are covered with flannel cloth, which is kept constantly damp. Often the young fish, soon after being hatched, are dispatched by train or boat to other stations to be turned loose in neighboring waters, and the steam launch is especially useful for this purpose, as the flat is frequently stationed fifty or a hundred miles from a railway station or steamboat landing.

We are informed that an official report will be published shortly respecting the piscicultural work of the Fish Hawk, and those of our readers who are acquainted with the complete manner in which the United States Government lay the information officially obtained, before the public, will easily understand that the most elaborate description of the system we could pretend to give would sink into insignificance compared to the minute comprehensiveness of the United States official report. For the above particulars we are principally indebted to the courtesy of Mr. R. Edward Earll, member of the United States Fish Commission, who is the specialist in charge of the exhibit at the Fisheries Exhibition.

Beside the model of the Fish Hawk is a model of the United States steamer Albatross. This vessel is also the property of the Fish Commission, but in place of doing the practical work of hatching and distributing fish, is used only for purposes of scientific research. As this vessel is expected to cross the Atlantic shortly, and arrive in the Thames in order to form a part of the Fisheries Exhibition, we may possibly have something more to say about her at a future date.

AMERICAN SURF BOATS.

Another exhibit from the United States of great interest is that presided over by Lieut. Chas. H. McLellan, U.S.R.M., who is assistant inspector of the United States Life Saving Service. There are two models on this stand which illustrate what can be done in a breaking sea by good watermanship with the simplest description of craft. The first of these models to be noticed is the New Jersey surf boat, which is used by the men of the Life Saving Service for launching from the beach through the heavy surf which rolls in from the open Atlantic. They are simple open boats of about 28 ft. long and 6½ ft. beam, with a depth of 2 ft. 5 in. They have 5 in. to 6 in. of camber on the bottom but are entirely keelless, as one of the leading necessities is that they should float in the smallest depth of water possible, in order to facilitate launching through the surf. These vessels have a very bold sheer, being about 2½ ft. lower in the waist than at the ends. They are clinker built, which is quite a rarity for an American boat, and copper fastened, excepting the butts of the strakes, which are secured with galvanized nails. The timbers are of white oak steamed and bent, while the planking is of cedar. The scantling is very light, and everything is done to save weight, the boats evidently depending principally on their buoyancy for their seaworthy qualities. In the model shown are two air tubes made of zinc, which are fastened under the thwarts, but we are informed that many of the crews discard these tubes as not being worth their weight, so that the boats, in case of being stove or water coming on board, would have very little more buoyancy than that due to the wood from which they are built; there are two canvas tubes stuffed with cork lashed outboard to each gunwale, but these, on account of their small size, can be regarded as little more than fenders.

Besides the models, which vary slightly in detail, there is an actual boat of this description in the grounds, and also two others from different districts, but which are used for the same purpose. The Long Island surf boat is much like the New Jersey boat, above described, the principal difference being that, while the latter has a transom very much raked, the former is "pink sterned" like a whale boat. The Long Island boat is lean in the run but has a rather full entrance, the object being that she shall lift quickly on launching. A boat such as this will weigh complete 800 lb. She will row six oars, and is steered by an oar 22 ft. in length at the stern. These boats are never fitted with sails. The Virginia surf boat, a specimen of which is also shown, has what is called in America a dory stern, that is to say, she has a very narrow transom a good deal raked, and a perfect triangle in form, which extends from the heel of the boat upward, the strakes being fastened to it. There is, therefore, no stern-post proper, although the transom is so narrow that it would hardly be a misnomer to style it a post. From the fact that this boat has a sliding center keel, one would imagine that she could hoist a sail at times, but this is not the case; the keel is simply used when the boat is being rowed with a beam wind in order to prevent her making excessive leeway. Considering the buoyant nature of these craft, this no doubt is a valuable addition.

These boats will, no doubt, be examined with interest by many English beachmen. That vessels apparently so fragile can be launched and beached through the heavy surf that breaks on parts of the Atlantic seaboard of the United States, and even more surprising still, go alongside vessels aground or riding in a seaway, will appear almost incredible to many solid Britons accustomed to stout British craft. Solidity, however, does not always give the greatest strength or durability; for instance, a powerful man would try in vain to dash an inflated bladder to pieces on a beach, while a single throw would serve to shatter a bowlder of much greater strength, but at the same time of more weight and less elasticity. The simile may perhaps be rather far-fetched, but serves to express our meaning.

AMERICAN LIFE BOAT SERVICE.

The United States Life Saving Service, which exhibits these boats, is an important Government department. The Americans are fortunate in having the whole of their marine life saving service centralized under one executive, of which General Superintendent Summer J. Kimball is the head. An annual appropriation of 500,000 dollars is made for the support of this service. There are nearly 300 stations in different parts of the Atlantic and Pacific coast lines and on the shores of the Great Lakes. From Cape Cod to Cape Fear, a distance of about 700 miles, there are stations at every three or four miles. Each station is manned by a company of seven surfmen and a captain or station-keeper, the men being paid fifty dollars a month, while the keeper receives seven hundred dollars a year. The ocean stations are occupied during the winter months by a full crew, but during the summer only the keeper resides in the station, and after every storm he is required to make extended excursions along the coast in order to ascertain if any shipwrecks have occurred, and to find and succor any person that may have been cast ashore.

In the winter two men leave each station four times every night, and walk along the coast until they meet the patrol from the adjoining station; so that during the winter the whole of the coast line from Cape Cod to Cape Fear is constantly being watched at night in order to discover wrecks or vessels standing into danger. Each man carries Coston signals, and should a vessel be discovered steering into shoal water, he ignites one of these, which emits a brilliant red flame of about two minutes' duration. By means of these signals forty-seven vessels were warned off last year, which would in all probability have been wrecked had they been left to their own devices. Should a vessel get aground, steps are immediately taken to launch either the surf boat or life boat, or else to set up communication with the ship by means of the life gun and line, which is the American equivalent to our line and rocket system exhibited by the Board of Trade in an adjoining building.

THE AMERICAN LIFE GUN AND LINE.

The gun used in the American system, known as the Lyle gun, is a small brass piece weighing 152 lb.; it throws an elongated projectile weighing 19 lb., the charge varying between 3 oz. and 8 oz. according to the distance and strength of wind, etc. The extreme range of the gun is about 650 yards. Attached to the projectile is an iron shank with an eye forged at the end. When the gun is to be loaded the shot line is bent to the eye of the shank, a fathom or two having been previously wetted. The shot line is formed of plaited flax and is $\frac{7}{16}$ in. It is drawn through a preparation of hot wax and paraffine in order to preserve it from damp, but more especially to reduce the friction when the line is drawn rapidly through the air. Upon the projectile leaving the gun it makes one-half turn, so that the line is towed snugly from the after part of the shot; for it will be obvious that the line must be made fast to that part of the projectile which is nearest the muzzle of the gun, and were the shot not to turn over this would afterward be the part furthest from the coil of shot line alongside of the gun, and the rope would tow from the fore part of the projectile, which would render the direction uncertain. The slight drag of the line is sufficient to cause the shot to be reversed immediately after leaving the muzzle. This principle was illustrated some time ago by some experiments made at Woolwich, and created a good deal of interest at the time. Upon communication being made with the wreck by means of the shot line, the crew of the stranded vessel have to haul a light whip on board, and by means of this a 3 inch hawser which has to be made fast to some part of the vessel. A breeches buoy is then hauled aboard by means of the whip, it running on the hawser, being attached thereto by a snatch block. The crew may then be landed much in the same way that is practiced by the English Coast Life Brigade. The Americans, however, have an apparatus, known as the Francis life car, a model of which is shown in operation. This is simply an inclosed vessel or chamber, 12 feet in length, and in appearance not unlike a large ill-shaped decked boat or canoe. The life car travels on the hawser in the same way as the breeches buoy, and five or six people can be packed inside it and fastened up, so that they might be hauled ashore through the surf without so much as getting wet. It cannot be a pleasant sensation, but probably to the ordinary landsman or passenger it would be preferable to having his legs thrust through the breeches buoy. The original Francis car is shown at the Exhibition. The first time this was used, in 1850, 251 persons were safely brought ashore by it from the British ship Ayshire.

On every station the crew go through a weekly drill of all the evolutions connected with their duties. Lieutenant McLellan has prepared a manual of the drill, which is printed by the United States Government for use in the service. The men are numbered as in a gun's crew, and each has his particular duty assigned to him on whatever service he may be engaged. A small manual has also been prepared for masters of vessels, and this is given to any one connected with a seafaring life, and, in fact, the officers of the service seize every opportunity of getting it placed on board ship.

The Life Saving Service is also engaged in salvage operations. Last year they rescued over three million dollars' worth of property in addition to the 1,386 lives they saved; the total number of lives lost only amounting to 12. They gave 1,378 days' succor to shipwrecked persons in distress, besides, as we have mentioned, warning 47 vessels that were standing in imminent danger. For these services no charge is made by the State or by those employed in the service, either by means of salvage or in any other way. Of the three million dollars' worth of property saved the whole advantage went to the owners, the service often being actually losers by the operation of rescuing the goods.

The service has achieved considerable success in restoring persons apparently drowned. Their system is slightly different in detail to that pursued in most other countries, although it is founded on the same principles. There are official reports made on each case that comes under operation. One sheet we examined details the rescue of a man 28 years of age, who had been under water for ten or twelve minutes. The jaws were clinched, and there was every outward appearance of death, but after artificial respiration had been continued for two hours and fifty minutes the man showed signs of life and ultimately was completely restored.

On the whole it would seem that the American people have good reason to be proud of their Life Saving Brigade, and we can easily believe that those connected with the service value their positions very highly.

THE FUEL OF THE SUN.

AT a recent meeting in Brooklyn, N.Y., of the American Astronomical Society, the subject for discussion was "The Fuel of the Sun."

Professor Young, of Princeton, opened the discussion. He said that to account for the heat of the sun there might be some truth in Helmholtz's notion that the sun is fed on its way through space with meteors attracted to it by its immense mass. If this theory were true, then the earth ought to get as much heat from shooting stars as from the sun, and the surface of this globe would have three tons of meteoric matter to the square mile. Yet in some way this objection could be explained away. If we are to suppose that heat is derived from matter distributed through space, we should first remember that the matter would make itself felt on the planets of the solar system. Professor Proctor must be wrong in saying that this does not necessarily follow. Another thing, if, as some suppose, a current of meteors toward the sun existed, then mischief would be played with comets. They would encounter resistance. Then, too, the temperature of the sun would not be hotter from such meteoric combustion than the carbon points in the electric light. Prof. Young had always supposed that the heat of the sun was not less than 10,000 degrees Centigrade. Yet, as a very slight increase of heat produces an immense amount of radiation, the heat of the sun might be lower than he had supposed; yet he could not believe it as low as that of an electric light. Another puzzling theory had been proposed, viz., that the sun sent its heat only to that which receives it, only to each of the planets, while space outside of a direct line from the sun to the planet remains cold. The trouble with that theory was that heat radiated on all sides and in waves, not in one direction only. The advocates of the theory said that solar heat acted like the law of gravitation. Finally, there was a theory that solar heat came from the contraction of the sun's body, but the objection to the theory was that it put a limit to the universe. If it is a true hypothesis, then the sun could not be more than 15,000,000 years old, and it could not continue to give heat more than 15,000,000 years. Such a limitation is not to be thought of.

President White said he was inclined to believe in the meteoric combustion theory.

Mr. G. D. Hiscox then read a paper on the subject, of which the following is the substance:

The problem of the source of energy of our great central luminary is now receiving the best efforts of the astronomers and physicists of the world for its solution; as yet it only takes shape and directions in theories more or less sustained by observed phenomena; but still narrowing the limits of speculation to within a circle in which it is hoped future observations and deductions will lead to a rational if not a positive resolution. The views and speculations of the old astronomers as well as those of some of the later physicists may now be safely set aside as founded upon the idiosyncrasies of their habits of investigation, together with the observed phenomena derived from inadequate instruments. In view of the entire revolution in the methods of solar physical research as established by the use of spectroscope, photography, the spectro-bolometer, and the great advance in telescopic power and definition, it can be safely said that the theories founded entirely upon the principles of cumulative combustion will best bear weeding of some of their claims. It is hoped that by weeding out the weak points of former observations and deductions, and discarding their absurdities, it will be possible to so narrow the circle of mystery that has heretofore surrounded the physical nature of our solar system that the path of truthful investigation may be found near at hand. Among the investigators of solar physics there seems none more prominent than Mr. Faye, in France, who has largely contributed to the sum of knowledge in regard to the mathematical or arithmetical energy of solar radiation. He has come to the conclusion that the vast amount of heat radiated from the sun's surface for probably many millions of years is so great that no natural force could have stored it in any layer of moderate thickness, and that therefore the sun's whole mass must have participated in the loss of heat during this long interval. In this consideration, how it is that the whole solar mass can thus communicate its heat to the surface, and by what mechanism does this enormous current of heat come to the surface, is the mystery of the sun's physical and mechanical constitution, which we can only rationalize by long and persistent observation of the wonderful phenomena exhibited upon its surface. It is further suggested by Faye that the photosphere, being more luminous than the purer hydrogen of the chromosphere, may safely be said to be made up of the denser vapors of all the chemical elements of the sun. That by the high heat of the interior these elements are driven to the surface, where by radiation they are partially cooled and become intensely luminous in the region of the photosphere; then, falling into the depths of the sun, are again dissociated and receive an outward impulse by the repulsive and expansive power of the greater central heat, therefore indicating that the whole mass of the sun is gaseous, with its interior under a high degree of compression, while the temperature of the interior must be far higher than that of the surface. This interchange of the elementary matter from the interior to the surface, its partial cooling, and return toward the interior, as portrayed by Faye, may in a measure account for the wavy surface or faculæ that seems an important feature of the sun's surface that has heretofore received less attention from observers than is due to its importance, arising from the difficulty of individualizing and recording its motion.

While the sputtering or violent ejection of hydrogen and the streamers of denser metallic vapor, likened unto the bursting of globules of steam from boiling viscous masses, particularly as observed in masses of molten iron and steel,

indicate as far as analogy goes the fact of a violent evolution of heat from the interior to the surface; the revelations of the most powerful telescopes show the sun's surface as full of small holes called pores. These pores are probably small sun spots, or it is stated that the larger sun spots have been observed to begin at one of the small black spots or pores. It has also been observed that the chromosphere appears depressed at and near these spots or pores; it therefore becomes reasonably apparent that they are at the surface of the photosphere, and are the nuclei of descending currents, while the faculæ are the apices of ascending currents, carrying the highly heated, dissociated elements of the sun, such as silicium, magnesium, calcium, and other metals, to the surface, where it is partially cooled by radiation to a point of intense luminosity, and from which by its increasing gravity tends to move off toward points of depression, of which the pores and darker spaces between the faculæ are the natural courses, thus keeping a constant circulation from the interior to the surface condensation, luminosity, a return to the interior, dissociation by absorption of heat, and again sent upon the outward round of circulation. There seems to be a limit to the amount of heat that could possibly be produced or added to the sun's energy by the concentration of cosmical matter, other than by contraction, which must unite with a heat-producing medium for development; and also of the impact of meteoric matter, which may contribute a small amount of heat as well as volume to the sun's mass, and to which may possibly be attributed the origin of the sun spots whose ragged and irregular contour seem better to conform to this mode of origin in many instances than to cyclonic action. Perhaps cyclonic action is normal to the sun's surface circulation, and meteoric projectiles only generative in their effects. The highly attenuated interplanetary zone which we term the zodiacal light may also add heat or fuel to the sun by its gradual contraction and condensation, as well also to absorb a part of its intense radiation. If the theory of La Place, vivid as it is in beauty and vastness of conception, be accepted, the condensation of cosmical matter should still be going on, and not cease until the sun itself becomes a solid mass, and the solar system enshrouded in darkness. The condensation of interplanetary matter, the corona, and the impingement of meteoric matter, contributing as they probably do a portion to the heat and energy of the sun, yet we can conceive of no equivalent in these elements to compensate for the volume of heat and light radiating into space. Again, if there exists an ethereal substance in space sufficient to maintain a combustion in the sun equivalent to its immense radiation, it would be dense enough to influence and retard the motions of the planets, and still further, to interfere with the periodicity of comets. The extraordinary coincidence of the agreement of the orbits of the great comet of 1843 and that of comet A of 1880, seems to leave but little doubt in the minds of leading astronomers as to their identity. If it should be proved so by a third coincident return, it will no doubt set aside the arguments for a resistive medium worthy of computation, although, near the sun and extending beyond the point of perihelion passage of many comets, there is no doubt an as yet uncondensed resisting medium that lends its retarding influence to passing bodies, and, for as much as we yet know, may be the real and principal cause of the erratic course of many comets after their perihelion passage. Again, the evidences furnished by geological research are becoming more convincing that the earth is receiving from the sun less heat now than it did ages ago, or during the middle geological periods, when its surface ceased to be influenced by its internal heat. The rate of decrease is so small that it cannot be measured by the record of man; it can only be made evident by the comparative changes in the flora and fauna of the earth, from the abundance and magnitude of its fossil exhibit, to the scantiness of its present existence. The amount might not be a fraction of a degree in a thousand years. The sun's apparent constancy of radiation may be partially if not wholly accounted for by the decreased absorption of the interplanetary matter constituting the zodiacal light, and the more dense mass in immense proximity to the sun, the existence of which was so fully shown in the observations of the eclipses in 1878 and 1880, and beautifully illustrated in the late publication from the National Observatory. Their illuminated aspect seems to indicate that light and heat are absorbed in their passage to the planets, and therefore, if a condition of constant contraction has been and is going on, the sun's effect will appear to be constant, or nearly so, although really losing heat and decreasing in temperature. There remains another element which seems to be a part of, and to have a strong interplanetary relation, being one of a mysterious triad, whose functions appear so interwoven and unchangeable that they are yet an enigma to mankind. Its sphere of greatest activity is upon the verge of vacuity; it exists as an almost unknown and pervading element of all matter, and, for all we know, of all space. In its dual nature we recognize a latent and active principle. It is developed by interchange of chemical elements, and by its power the strongest bound elements are reduced to their simple terms. Certain functions of each of the triad are common terms, while others are widely different or antagonistic. This element, electricity, together with its magnetic brother, seems to possess energies scarcely yet understood; these may be, so far as we know, only derivative functions of each other. Heat and light being strongly developed by electric energy while passing in contact with natural elements where these elements are disrupted or transposed, as in the carbon light and atmospheric discharges, as well also in the mysterious incandescent or vacuum light in which there is no disturbance of any material element, but a development of heat and light by its mere passage through or over an element of slight resistance, showing visibly that its sphere of light and heat-giving activity lies upon the verge of vacuity. From the well-known conditions of light, heat, electricity, and magnetism, in their generative and inductive relations to each other, and the admitted powerful and almost simultaneous magnetic relation between the sun and the earth, it is inferred that all interplanetary space has no bar to its instantaneous and coincident effect.

From the progress that has latterly been made by Mr. Crooke in the study of the molecular physics of electricity in high vacua, it is hoped a long stride forward will be made in the knowledge of the probable influence this mysterious element may bear in the heat and light-giving power of the sun. The ideal of the existence of subtile fluids and molecular vibrations with their interchangeable tensions and intensities, as representing the elements of sound, heat, light, electricity, magnetism, and gravitation, are as yet a ladder in the mystery of creation in which every step forward in the investigation of ultimate elements is one round higher to a knowledge of the infinite.

METEORS.

By R. J. McCARTY.

HISTORY records many instances of the fall of masses of stone, iron, and other substances from the higher regions of the atmosphere. Until the beginning of the present century these records were regarded by many as either entirely mythical, or based upon some events entirely susceptible of explanation from local causes, so that there was hardly sufficient faith in the fact to stimulate the philosopher to search for the cause. But when on April 26, 1803, near L'Aigle, in Normandy, a shower of stones followed the explosion of a fiery globe which rushed with great velocity over that region, and when this fact was officially verified by a commission of the French Government, there was left no room for doubt that meteoric light is often followed by the precipitation of matter to the earth.

From observations made of the instants of appearance and disappearance of the light and of the position of its path with respect to the stars, astronomers have been able to calculate that the source of meteoric light lies always within the limits of the atmosphere, and that the velocity of the meteor varies from seventeen to thirty-six miles per second.

It is, therefore, impossible to doubt that meteors are masses of matter rushing with tremendous velocity through the air.

But this amounts to little more than a definition and does not explain the physical causes of the phenomena, and the questions arise: Whence the light by which we know the meteor, and whence the matter of which it is composed?

Now it is known that resistance to motion will always generate heat, and that great heat is always accompanied by light. For instance, an axle or journal, if not properly lubricated, while rapidly rotating under great pressure, will become red hot, and the reason it does not become red hot when lubricated is that the oil reduces to a great extent the resistance due to friction, and at the same time absorbs the heat generated by the resistance which it is not able to destroy.

Moreover, we know that the atmosphere offers resistance to the passage of bodies, proportioned to the square of their velocities.

Experiments in gunnery show that a fifteen-inch shot moving with a velocity of 1,500 feet per second encounters an atmospheric resistance of about one and one-half tons. If such a shot could be given a meteoric velocity of thirty miles per second, equal in round numbers to 150,000 feet per second, the resistance would be increased to about 15,000 tons. The quantity of heat generated by such a resistance under such circumstances is unknown, but reasoning by analogy from the above instance of the red hot axle, it seems perfectly reasonable to conclude that sufficient heat would be evolved to ignite and perhaps dissipate many rigid and practically incombustible substances. It is therefore generally conceded that meteoric light is caused by heat developed by the atmospheric resistance incident to the great velocity with which such bodies are known to move. If the meteor is composed of matter sufficiently fixed, a portion of it often survives the great heat and falls to the ground in a highly heated state. If it is composed of more inflammable material, it is consumed and dissipated in the air, which explains why we may not expect a meteorite from every meteor.

Respecting the origin of meteoric matter, many theories have from time to time been advanced. For instance, it was supposed by some to be formed by the condensation of vapors of various substances in the air in a manner similar to that by which hailstones are produced from the vapor of water. The absurdity of this is manifest. La Place, with more reason, supposed that such matter was cast from the moon by volcanic action with such force as to be brought within the limits of terrestrial gravitation, and, indeed, considering the absence of atmospheric resistance on the moon (for that luminary has little or no atmosphere), and considering that the force of gravitation at the lunar surface is but one-fourth what it is on the earth, it is not impossible that the tremendous volcanic action peculiar to the moon might accomplish such a result; but, as will appear further on, such a supposition is incompatible with the general facts attendant upon meteoric phenomena.

It happens that mechanical science is able to demonstrate that meteoric matter is entirely foreign to the earth or moon, thus:

The greatest velocity with which a body, moving under the action of terrestrial gravitation alone, could possibly strike the earth, would evidently be attained by letting the body fall from an infinite distance—and it is demonstrated by a well known theorem in dynamics, that under such circumstances a body would strike the earth with a velocity of about seven miles per second; but we have seen that meteors move with velocities varying from seventeen to thirty-six miles per second, so that they must have a velocity not due to the earth; which is but another way of stating that they must have a planetary motion.

Therefore meteors are cosmical bodies; that is, bodies having their origin in the same general cause which produced the sun, moon, and stars, so that they may be regarded as minute planets or comets moving around the sun, obeying the same laws and controlled by the same forces which order the motions of the most gigantic planet of our system.

When we consider that between the orbits of Mars and Jupiter there are more than two hundred small planets, varying in size from two hundred and fifty to sixteen miles in diameter, and that others are being discovered every year, it seems entirely reasonable to conclude, even without reference to meteoric phenomena, that there are myriads of such bodies belonging to the solar system so very small that they can never be detected.

And meteoric phenomena show that the orbital motions and positions of these small bodies are such as occasionally to bring them within the dominion of terrestrial gravitation, whereupon they are drawn from their orbits toward the earth with increasing velocity, and striking the atmosphere burst into flame from the causes given above.

However satisfactory it may seem in explaining the ordinary meteor, which may be seen on almost any clear night, to flash like a rocket across the sky, it would be spreading the above reasoning over too much surface to extend it to those periodical phenomena, called meteoric showers, which make it appear as if all the stars in the heavens were being precipitated upon us.

It having been observed that all planets revolve around the sun in the same direction and nearly in the same plane, and that the sun himself rotates in the same direction about an axis near perpendicular to the mean position of the planes of the planetary orbits, the suspicion arose that this could not be the result of chance, and that therefore the mechanism of the solar system must derive its motions from a single physical cause—and indeed it has been demonstrated that the probability for a single cause for 228 planets moving in the same direction around the sun is $1 - \frac{1}{2}{}^{228}$ in which 1 represents certainty. The fraction $\frac{1}{2}{}^{228}$ when developed would be represented by 1 divided by a number of sixty-nine figures, so that the valve of the fraction would be almost nothing, which shows it to be a practical certainty that such motions are the result of law and not chance.

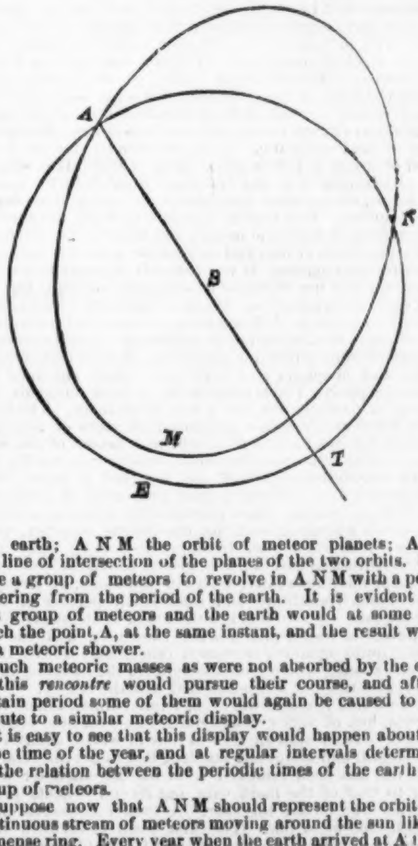
The attempts to discover this law, directed somewhat by the suspected existence of gaseous nebulæ, culminated in the nebular hypothesis, which resting as it does upon such a high degree of probability, conforming so entirely to natural law, and explaining so many phenomena entirely inexplicable on any other theory, may be regarded as established as fully as any speculative principle can be without becoming a fact or truth.

Broadly stated, it is as follows: At one time all the members of the solar system were united in a single mass of blazing matter rotating about an axis nearly coincident with the present axis of the sun, and, by reason of the expansion due to excessive heat and the operation of centrifugal force, extending its lenticular form far beyond the orbit of the outermost planet. By the process of cooling, the action of centrifugal force, and the law of gravitation, the outer portions of this chaotic mass became detached from the main body and broken into small fragments, thus forming an immense annulus, each member of which revolved around the original mass, just as planets revolve around the sun. Some of these fragments afterward became united by gravity and collision, and the result was a larger mass continually increasing in size by absorbing its smaller neighbors, just as the earth now absorbs meteoric matter, and still revolving around the original mass. By a repetition of this process at the different stages at which the centrifugal force, increasing with the increase of velocity due to the gravitation of the denser portions of the nebula toward its center, would balance gravity, the solar system as it now stands was formed, the sun being the remnant of the original chaotic mass—all of which, judging from the behavior of matter under somewhat analogous conditions here on the earth, is in perfect conformity with physical law.

Now, unless we are prepared to combat the nebular theory we must admit that at certain epochs of its development the solar system was swarming with millions of small meteor-planets, that these have either all been since consolidated into the masses of the few larger planets, or that there are some still remaining, which, owing to their peculiar situations and motions, have escaped the clutches of their more powerful neighbors.

The latter is by far the most reasonable, since it is difficult to conceive how all these small bodies, moving as they do, could be absorbed by the larger in any finite time—and here it may be well to remark that it must be owing to the great distance between the orbits of Mars and Jupiter that the asteroids have not been appropriated by one or the other of those planets, and to the peculiar positions of their orbits that they have not been united in a single mass. The nebular hypothesis therefore permits us to assume, if it does not force us to believe, that not only are there many small isolated bodies revolving around the sun as planets, but also that these bodies revolve in groups and even in continuous rings.

Suppose that one of these small bodies should revolve in an orbit of exactly the same period as the earth. It is evident that so long as this was kept up the small body would preserve its identity, but should its period be changed in even the smallest degree, it would become a question of time when the earth would transform it into either a meteor or satellite. Let S represent the sun; A N E the orbit of



the earth; A N M the orbit of meteor planets; A S T the line of intersection of the planes of the two orbits. Suppose a group of meteors to revolve in A N M with a period differing from the period of the earth. It is evident that this group of meteors and the earth would at some time reach the point, A, at the same instant, and the result would be a meteoric shower.

Such meteoric masses as were not absorbed by the earth in this *rencontre* would pursue their course, and after a certain period some of them would again be caused to contribute to a similar meteoric display.

It is easy to see that this display would happen about the same time of the year, and at regular intervals determined by the relation between the periodic times of the earth and group of meteors.

Suppose now that A N M should represent the orbit of a continuous stream of meteors moving around the sun like an immense ring. Every year when the earth arrived at A there would be a meteoric shower. This is what happens each year about August 10th.

Thus far we have kept within the limits of the solar system entirely, in order to show that all meteoric phenomena could be accounted for within those limits.

But there are certain meteoric displays, notably those which appeared in 1799, 1833, and 1866, which cannot be

considered as coming within the limits of the above reasoning, because it is known that the group from which these meteors emanate has a retrograde motion, and moves in a cometary orbit. But this fact no more militates against our previous reasoning than do retrograde comets against the nebular theory. It only enlarges the scope of the inquiry, and shows that while many meteoric masses are proper to our system, they may also wander to us from the remote depths of space.

From what has been said we conclude that meteoric phenomena are but the continuation of that process by which the solar system has for infinite ages been collecting the scattered matter from outer space, and by which the planets have grown to their present size; that this process now retains but the shadow of its ancient vigor, and will probably slowly fade and finally vanish in the great end toward which all creation tends.—*Kansas City Review.*

THE ZINC MINES OF SUSSEX COUNTY, NEW JERSEY.

By NELSON H. DARTON.

AT Ogdensburg and Franklin Furnace, about sixty miles northwest of New York city, on the New York, Susquehanna, and Western R. R., are several veins of zinc minerals which are, without question, the most interesting formations of their character in the United States. They have been worked for a number of years, but are as yet apparently inexhaustible. They were discovered by Dr. Fowler, a large property holder and mineralogist of the vicinity, in 1815–16, who drew attention to the wonderful variety and association of minerals in the outcrops of the veins, and also to the great purity and immense quantity of the ore in sight. It was not long before the attention of some capitalists was directed to the district, and they leased from Dr. Fowler the privilege of working certain of the mineral veins. Since that time these veins have been extensively developed, and have long formed a mining center at Franklin Furnace. Formerly, many men were employed in their development, but now a less number is required, as the mining facilities have been increased.

At Franklin, on Mine Hill, within a hundred feet are the veins of magnetic iron ore, graphite, Franklinite, forty feet or more in thickness, and lying upon beds of pyroxene and garnet rock; and in the limestone, then the vein of zinc ore—besides which at Ogdensburg there are two other zinc ore veins, and thus there are three, which are included between walls of granular limestone, which a few feet beyond are adjacent to walls of gneiss, or in some instances syenite or granite. The localities are two in number: First, the two veins known as the West and Main vein at Ogdensburg, in Sparta township, and the vein two miles north at Mine Hill, in Franklin. The former veins are divided into three mines known as the Manganese, New Jersey, and Passaic—the later mine being at present the only one worked. The Ogdensburg veins are very peculiarly arranged, and it is not until lately that their true configuration has become known, as pointed out by me in a paper read before the New York Academy of Sciences in November, 1882. On the geological map of the veins, published with the survey report in 1868, they were mapped as being one, and that similar in arrangement to the vein at Mine Hill, with a crook toward the northwest, the latter having a crook to the northeast; both form the southern ends of the veins. The juncture of this crook was represented as a sharp point, and diverging at an angle of about 35° from the main vein. This is true at the Mine Hill vein, but at Ogdensburg the relations are quite different, as there are two distinct veins essentially parallel and at several hundred feet apart at their southern terminations. But entirely separate from them are two high basins, two hundred feet in diameter, and about 80 feet in depth. The main vein is two thousand feet in length, and twenty-two feet in thickness at the surface and decreasing very gradually as it descends. It is surrounded by complete walls of dolomite, at least to a depth of eighty feet. The ores that occur in it are the following: Zincite, a red oxide of zinc containing about 80 per cent. of zinc, the red color being caused by the presence of scales of red oxide of iron disseminated through it. This ore is a much valued one, and constitutes a large percentage of the average ore. It is used directly for the production of either spelter or white oxide of zinc. It is mixed in all proportions with the mineral Franklinite in small black grains, or modified octahedrons containing iron, zinc, and manganese. This mineral is separated from the zincite by mechanical or magnetic means, and used for the production of compounds of iron and manganese, known as spiegeleisen or ferromanganese. It was formerly rejected as worthless, not being of use in manufacturing zinc or iron, but is now a valuable production. Besides, there are several impurities: Rodonite or silicate of manganese and tephroite; its unisilicate; rhodochrosite, its carbonate. Small amounts of silicate of zinc, willemite, also occur, besides carbonates, of zinc and magnesia and very appreciable amounts of silicate of copper. The arrangement of these minerals in the vein is very peculiar, and I will detail them. The foot wall of dolomite, as before mentioned, is more or less impregnated, for about a foot in depth, with masses of zincite, holding a little franklinite and some tephroite, generally in large defined crystals. Above this is a bed of zincite, six feet in thickness, containing a small proportion of granules of franklinite and at times considerable silicious matter. Above this is a hanging wall, not continuous, however, impregnated with rhodonite, franklinite, zincite, tephroite, and rhodochrosite, and in a few places blend. Above this is the main vein, about twelve feet in thickness, of zincite, holding much franklinite and some small portion of the other minerals. Above this is a thickness of about one foot of a mixture of franklinite, zincite, rhodonite, and rhodochrosite, quite separated from each other, and above this some pure zincite, which joins the veins to the hanging wall, which is also more or less permeated with the zincite.

The west vein is not of the even, regular dimension of the main vein, but of very crooked outline and variable widths and depths—from sixteen feet to four in width, about 150 feet in length, and about one hundred feet in depth. Nearly all the ore has been removed from it. Its character was similar to that of the main vein, but its constituents quite homogeneously mixed together. A tunnel connects this vein with the main one. The first basin is between the southern ends of the veins, the other just south of them; both were half filled with dirt when found, but under this was a thick bed of franklinite; and under this the calamine, a silicate of zinc containing water. It was much mixed with dirt, but this is readily washed out, and is one of the most valuable outputs of the mines. When it is mixed with lime and distilled, white oxide of zinc is obtained. Its color proper is pure white, and many specimens in this condition have been found. One a cylinder forty feet long, two to three feet in diameter, and with walls about two to four inches in thickness of a pure white color, lying upon an incline up the basin, evidently at one time a water course. Many other specimens of various minerals have been found in this basin, especially some crystals of jeffersonite fully a foot long and perfect in every angle.

The Passaic Company, the only one at present at work, have developed mines for some time. The principal mine is in the main vein, from which 50 tons per day are taken, and the basin where the silicate or calamine is taken out. A large engine house is erected nearly over the mouth of the main vein, which has a shaft 240 feet in depth and works two drills. Two forty horse power boilers are in the engine house, working an 8 inch mining pump with 5 foot stroke, an air compressor, a No. 5 Blake pump in the level, and a No. 1 Worthington double action pump in the bottom of the shaft, besides some smaller machinery in the shop, the hoisting engine, etc.

At the calamine mine a few hundred yards away a small portable hoisting engine is used, and at the mills for washing it at the bottom of the hill, a six horse power Hoadly engine for running the stamps, washers, and a No. 5 Knowles pump, 10 inch cylinder, 16 inch stroke. The washed silicate is dried in heaps and shipped direct to their works, or in some instances sold to other companies. The able superintendent is Mr. T. M. Mitchel, who, assisted by about sixty men, attends entirely to the work, and it is since he has been with the company that the true width of the vein—22 feet—was ascertained. The vein of lean ore hiding the rich layer of zincite six feet in thickness was formerly considered the foot wall of the vein until explored by Mr. Mitchel.

At Mine Hill in Franklin the zinc is again found in nearly a direct line northwest; the Ogdensburg deposits in a vein of nearly the same length, but in many places forty feet in thickness, of quite homogeneous composition, and apparently inexhaustible. It has been much mined, but now only one opening is worked to any extent, which is the Buckwheat Field mine on the crook of the vein. Here is a monstrous opening, several hundred feet in length, forty in width, and seventy in depth, approached by a tunnel from the valley of the Walkill River a distance of a thousand feet, and by ladders up its side. There is a shaft about a hundred feet deep in the opening and ramifies out into the vein. Opening from the north is a huge grotto where they are now taking out ore. The entrance to this part of the vein was barred by a huge dike, apparently the end of the vein, it being forty-five feet in thickness, and at right angles to the vein. Behind it the continuation of the vein was found; the grotto having assumed large dimensions by the removal of the ore, which is composed of zincite, franklinite, and willemite, or green anhydrous silicate of zinc, besides some minor constituents. When mixed with lime and distilled, the oxide of zinc distills off, the silica of the willemite combines with the zinc, and the oxide of zinc, thus freed from its silica distills also, and thus this otherwise useless product is valuable. The mining is very simple here; compressed air drills are used; the ore blasted out with giant powder, placed on cars, and drawn by donkeys through the tunnel to a small platform, where it is weighed and dumped directly on the cars for shipment to the company's works at Newark or to Jersey City. An engine for hauling ore from the mine below the opening to the donkey cars and for compressing the air for the drills is the only machinery employed besides a small mine pump below the opening.

THE BEST METHODS OF ESTIMATING THE FOREIGN CONSTITUENTS OF IRON.

A. TAMM contributes the following paper on analytical method to the *Jernt. Kont. Annaller:*

Carbon.—In England and Germany the carbon is usually estimated by dissolving the iron in ammonio-chloride of copper, collecting the insoluble residue on an asbestos filter, drying and burning it in a combustion tube. The carbonic acid formed is collected by absorption in caustic potash, and then weighed. In Freiberg the carbon is oxidized with chromic acid instead of oxygen, which requires more practice. In France the iron is dissolved in mercuric chloride, according to Boussingault's method.

By the English method 300 grammes of ammonic chloride of copper is dissolved in 1 liter of water, and 50 c. c. of this solution is taken for every gramme of iron. In the analysis of cast iron, at least 2 grammes must be dissolved, and in wrought iron 5 grammes. The solution takes place in half an hour if gently warmed and stirred, a few drops of hydrochloric acid being added. The total carbon remains. In most cases an estimation of graphite is unnecessary; but for this purpose the iron is generally dissolved in nitric acid, and the silica and graphite which are left are burned to carbonic acid. For exact estimations of graphite the Swedish iodine method is preferable.

Silicon.—It is estimated in England and America by dissolving in aqua regia or nitric acid, and evaporating it down with sulphuric acid, especially if there is much silica. In Creuzot and Terrenoire the pulverized iron is oxidized by moistening with nitric acid and igniting in a muffle, then heating in a current of oxygen and subsequently in dry hydrochloric acid gas, so as to convert it into perchloride of iron, which can be sublimed, leaving the silica behind to be subsequently purified.

Phosphorus.—Most of the methods of estimating phosphorus convert it into the yellow molybdate compound. From 1 to 3 grammes of iron are dissolved, either in nitric acid to which hydrochloric acid is then added, or in a mixture of both acids, more rarely in nitric acid alone. The first is the best and most common. In England equal parts of nitric acid (spec. grav. 1·4) and hydrochloric acid (spec. grav. 1·19) are employed. For precipitating phosphoric acid the ammonium molybdate solution may be acid, alkaline, or neutral; yet an acid solution is preferable, as it better prevents the separation of molybdic acid [The presence of an excess of ammonium nitrate is an advantage.—*Ed.*] The magnesia method is not to be recommended, on account of the large quantity required and its circumstantiality.

Sulphur.—For the estimation of sulphur, aqua regia is used to dissolve the iron, and this converts the sulphur into sulphuric acid, which is precipitated by barium chloride. Some chemists convert the sulphur into sulphureted hydrogen. In Freiberg the gases are passed into hydrochloric acid containing bromine, and then precipitated with barium chloride. Pattinson leads the gases into ammoniacal chloride of cadmium, the precipitated sulphide of cadmium is oxidized to sulphate by means of bromine acidified with hydrochloric acid, and then precipitated with barium chloride. The gases may also be passed into acetate of lead, sulphate of copper, or nitrate of silver. Rollet, in Creuzot, passes a current of purified hydrogen mixed with one-third its volume of carbonic acid through the pulverized iron heated to redness. When there is a large quantity of sulphur, he passes the gases into nitrate of silver and precipitates sulphide of silver. If there is but little sulphur, he passes it through a row of bottles, each of which contains 2 c. c. of a nitrate of silver solution of such strength that the silver corresponds to 0·0004 gramme of sulphur, or exactly 0·01 per cent. of the 4 grammes taken for analysis. The number of bottles precipitated gives the percentage in hundredths.

Manganese and Iron.—For the estimation of manganese and its separation from iron, ammonium acetate is commonly employed in England and Belgium, while sodium acetate is used in Germany, France, and Sweden. In England the percentage of iron is generally found by titrating with bichromate of potash, but in Germany, France, and Belgium (and America) the permanganate is used. In the presence of perceptible quantities of titanic acid, sodium sulphide can be used to reduce the iron, as it has no action on the titanium. In Sweden the crucible test is still in use, as it also gives much other valuable information. It gives the percentage of cast iron, not of pure iron, but this is rarely required except in ores very rich in manganese.

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